

The Arctic Region

General Description

The coasts and islands of the Arctic Ocean are treeless, wind-swept lands. Though ice-sheets and glaciers permanently cover large areas, yet much of the land, even in the farthest north, becomes open country in the summer, from which the snow melts for a short time. On these stony or swampy tracts, which are called the Barren Lands in the Western hemisphere, and the Tundra in the Eastern, communities of low plants succeed in living, a few members of which are cultivated in gardens.

Their conditions of growth are very severe. During the months of winter night, some powdery snow falls, but in no great amount, and not very often. The yearly precipitation over most of the Arctic is below ten inches, about half that of the driest part of Britain. The winter sky is often clear, lit by the Northern Lights, or the moon shining during any of the twenty-four hours and gleaming brilliantly on the ice. But the winds are unchecked, and are often so frozenly dry, sucking the last moisture from even leafless twigs, that they are the main enemies of plants, not the intensity of the cold. Lower temperatures occur in parts of the zone of coniferous trees far to the south. Even the scanty snow, which would protect, is swept into drifts by the winds, leaving large stretches bare to the frost.

The bitter cold lasts unbroken for some time after the sun has appeared above the horizon, until in May or June the weather quite suddenly becomes warmer. The masses of sea and land ice start to thaw, keeping the air cool in spite of the sun's heat. Wet fogs frequently lie on the land, and clouds spread over the sky. Where the sloping sun strikes directly on hillsides facing south, the surface soil becomes very warm, but even in these places the frozen ground never thaws deeper than a foot or so. In early September hard frosts return, and winter commences with little warning. The summer activity for plants lasts nowhere more than ten weeks, but in midsummer they have twenty-four hour sunlight and mature quickly.

In spite of the very low precipitation, much of the flat land is marshy, as the ground-ice stops drainage downwards and the cold and misty air checks evaporation.

These conditions of permanent frost below, and freezing and thawing above, cause characteristic ground structures to develop. How they are formed is not exactly known. Often in the far north the land lies in polygonal stony hummocks with muddy or sandy channels between, along which the water drains. Elsewhere, a layer of wet soil, squeezed between sudden freezing of the sur-

face above and the permafrost below, bursts upwards, heaving out any plants and leaving bare patches. On slopes, long wide ridges, held by frost, are formed downhill, while the water of the slight surface thaw pushes down the furrows between them, cutting them deeper, or causes whole muddied and softened hillsides to slip.

The soil itself of the Tundra, subject to this churning and moving, consists of the clay, sand and rock of the district, split by frost into lumps and fragments of all sizes, irregularly mixed. Percolating water in the summer sorts and redistributes the finer material along drainage channels to some extent. The scanty remains of plants form a little peat among the stones or stirred into the clay, but most of it is washed and collects to form black peaty mud in the hollows.

The various Tundra communities are much alike all round the Arctic Ocean. Though most of the plants are circumpolar, or represented by closely allied races, others are more limited in geographical range. Also the relative extent and importance of the communities alters as their living conditions ameliorate from the farthest north towards the south.

The northernmost region of all, the High Arctic, includes the north coast of Greenland, Spitzbergen and the Franz Josef Archipelago, the north Siberian islands, Ellesmere and other of the Canadian islands of the extreme north. Even in summer the High Arctic Barrens appear desolate, stony wastes. Low hummocks of stones, partly encrusted with lichens, and sparsely studded with small tufted plants, usually along the troughs, are all that can be seen. Of these, a few dwarf-shrubs hardly rise above the general level. The flowering plants push small mounds of vivid colour through their dead leaves of past seasons. Water trickles from snowbanks in innumerable rivulets, making shallow swamps, where sedge and grass tussocks, frost-seared at their tips, are the most lush growth in the whole country. The misty sun never sets, but the wind is cold.

Further south, on the northernmost peninsulas of Siberia, Novaya Zemlya, the coasts of central Greenland, Baffin Island, and the central parts of the north Canadian archipelago, the country becomes less barren. This is the land of the Mid-Arctic Tundra. The summer is a little longer, melting away nearly all the lowland snowdrifts. When the thaw sets in, the sound of running water is everywhere. Swamps and pools fill all the hollows over the permanently frozen subsoil. Soon these waters become noisy with flocks of wild geese, waders, and other waterfowl flying in from the south to nest among the sedges and cotton-grass. On the slopes between the marshes low heath-shrubs emerge from under melting snowbanks, growing close together over a carpet of thick moss or lichen. Only ridges swept clear of snow in winter are stony and largely bare. Here the plants of the High Arctic barrens are to be found scattered in tufts among the lichen-painted stones.

As one climbs into the mountains, the Rock-Tundra becomes more prevalent and extends on all sides as steep screes, frozen at a slight depth. Deep snowdrifts fill hollows and ravines, which melt very late, or not at all. At last only the rock-crag and cliffs stand above glaciers and fields of permanent ice. Even in the crevices of these high “nunataks”, a few lichens and tiny plants survive.

The southernmost region of the Tundra, the Low Arctic, covers southern Greenland, most of the north coasts of Russia and Siberia, and the north coasts of Alaska and Canada. The country is still treeless, but the ground is nearly all covered by low vegetation, and appears brownish-green or yellowish from a distance in the summer. Seen close at hand, different plant communities can be distinguished, marking different slopes and aspects, and different amounts of water in the soil. Even tangles of shrubby Willows and Birches are able to flourish in south-facing gullies. But the stony barrens of the High Arctic are still to be met with on windswept heights.

Much of the lowland country, where the soil is clay or loam, is covered with a carpet of mosses. Usually the mosses grow in raised tussocks, sometimes reaching a yard high and wide. Between the tussocks are wet furrows, also overgrown with other sorts of moss. Small flowering plants and dwarf-shrubs tuck themselves in the dense growth. Elsewhere, in drier parts, the tussocks are flatter, with bare patches or lichens between. The Moss-Tundra, mound after mound in all directions, extends for vast distances. But, here and there, in sheltered spots facing south, where snowdrifts melt and trickle, one comes upon slopes where the moss-carpet is nearly lost among many flowers, in bloom as soon as the snow has left them.

In other areas the soil is sandy, pebbly, or thin over rock, and drier. This is the country of the Lichen-Tundra, pale yellowish-grey expanses, often varied by the dark green of dwarf-shrubs. Here the Reindeer find their best pasturage, but if large herds stay long in one district to graze on the Reindeer-moss (which is a tall lichen), they spoil the pasture. The slow-growing lichens are so eaten back that they are smothered by the poor and wind-stunted dwarf-shrubs, and many years of recovery are needed. In these southern Tundras, as further north, much of the melted snow and ice cannot drain away in the brief summer. There are pools and lakes everywhere. All depressions, and even flat lands, are wet if not actually swamps, and can be recognized from afar by the faded yellow of their sedges. Near its southern limit, the Tundra develops another aspect. Ridges and hillocks of about a man's height, of moss-covered peat rise above bogs in which Sedges and the bog-mosses (*Sphagnum*) grow. Bands of scrubby Birch line the lower slopes of the hillocks, and spread into dense thickets on warm inclines. This Peat-hillock Tundra only forms in ocean-influenced regions of high precipitation.

Summary of Plant Communities of the Arctic Region

The various communities of plants which make up the Tundra are sometimes unvarying over wide areas, but more often, two or more communities alternate, forming a patchwork, or mosaic, which extends for miles. Also the communities merge into one another, or gradually supersede one another as conditions change.

Rock-Tundra, or Barrens. These are the typical High Arctic communities of the harshest wind-parched, frost-heaved conditions, and of the farthest north. They also spread south on windswept ridges, and above less hardy vegetation on mountain ranges. No more than half, and generally less, of the ground is occupied by plants.

Bogs and Poolsides. Communities of cotton-grasses, sedges, and grasses, with undergrowth of mosses, grow in the extreme north on greasy, dark mud on pool margins or in shallow water. Further south, species of *Sphagnum*, the Bog-mosses, appear among the cotton-grass, until at the edge of the forest, they occupy most of the swamp in thick, peat-forming mounds.

Moss-Tundra. Moss-Tundra occupies impervious clay and poor, slow-draining land. It consists of hummocks of upright-growing mosses separated by bare patches or muddy channels. It does not cover much country in the High Arctic, but miles upon miles in the Mid- and Low Arctic. On the windswept and dry tops of the hummocks lichens and dwarf heath-shrubs gain a footing.

Lichen-Tundra. Crustaceous lichens grow on bare rock in all parts of the Arctic from the farthest north to the forest. Foliose and fruticose (upright-growing) lichens occupy crevices, and form mats as soon as any soil collects. In the Mid- and Low Arctic, on soils too dry for typical moss-tundra, the larger fruticose lichens become predominant, and the mosses take a subsidiary place. Though the flat types of lichens can stand the most hard and windy conditions that any plant can survive, the taller kinds need some moisture in the atmosphere, at least in the summer, though their soil be dry. Heath-shrubs grow in the mat of lichens and may overcome them to form a heath.

Heath-Tundra. In the High Arctic, heath-tundra is found here and there in warm, snow-protected sites. It is widespread and characteristic of well-drained land which has a good winter snow cover, especially on siliceous soils, in the Mid-Arctic. In the Low Arctic, the heath-shrubs colonize the moss hillocks and share predominance in the damper parts of the lichen-tundra. Heath-Tundra is made up of low, mostly ericaceous, undershrubs, growing in a mat of mosses or lichens.

Sedge-Tundra. Communities of sedges with a few grasses occupy wide tracts of flat land in the Mid- and Low Arctic. Sedge-tundra overcomes the moss-tundra where more and richer soil accumulates and there is plenty of water, with enough drainage to prevent bog formation. The tussocky mosses, however, remain as ground-cover below the sedges. Even in the High Arctic, sedge-tundra occurs in places too exposed or wet for heath.

Meadow-Tundra. Mainly of short grasses and flowering herbs, patches of meadow-tundra grow occasionally on the warmest, south-facing, well-watered slopes in the High Arctic, on the richest soil. It spreads in the Mid- and Low Arctic to occupy slightly less favourable sites as well, especially along streams, as the climate ameliorates. It is also characteristic of ground manured either by the droppings of the enormous flocks of sea- and swamp-birds, or by the refuse of man's settlements. In the far north, deep, thick, evil-smelling moss carpets, with lush herbs and grasses; in the Mid and Low Arctic, close meadows of grasses, mark these places.

Cotton-Grass Tussock-Tundra. This is a type of tundra of Alaska and East Siberia. It covers many square miles with a hummocky patchwork. The cotton-grass (*Eriophorum vaginatum var spissum*) forms large tussocks. Sometimes the tussocks grow close together in stands of acres, sometimes only scattered. Both on the base of the hummocks and on their tops grow dwarf-shrubs. The low-ways between are filled with bog-moss (*Sphagnum*) or sedgy marshes. The community is a complex of wet sedge-hollows, dry heathy mounds, and the cotton-grass tussocks which give it an individual character.

Willow and Dwarf-Birch Scrub. Willow bushland needs deep snow protection and wet soil. It does not occur in the High Arctic, but appears on the sheltered bottom slopes of valleys, and invading the edges of the bogs in the Mid-Arctic. It extends its territory in the Low Arctic, until overcome in the south by scrub of the Dwarf-birches (*Betula* species), which takes its place on the slopes and confines it to wet streambanks.

Peat-Hillock Tundra. The peat-hillock tundra develops only at the southern edge of the tundra region, in areas with an oceanic climate. It is typical of the forest-tundra transition country. It develops from the more northern moss-tundra by the accumulation of peat, causing the raising of large hillocks. It is another complex of moss-bog in the channels, lichen and heath tundra on the summits, with Dwarf birch or willow thickets between. Peat is a good insulator, once frozen the summer sun cannot thaw deeply into it, and the permafrost is therefore much nearer the surface on the hillocks.

Salt Communities. Salt communities occur along the coasts, but are not very extensive. When the coast is sandy, low dunes are formed with sand-binding grasses, perhaps with brackish lagoons behind. Where there are estuaries of mud within reach of salt water, small, grassy salt-marshes are to be found. Boulderly or rocky coasts are scraped smooth and bare by floating ice.

Spitzbergen

Spitzbergen is interesting as a land very close to the Pole influenced strongly by its oceanic position, especially as it is in the path of the warm North Atlantic Drift. Its climate therefore is a little warmer in winter, and cooler and foggier in summer, than continental lands lying much further south. It is a group of High Arctic islands of jagged mountains, permanently snow-laden, rising among long arms of the sea. Glaciers descend from the mountains to give off small icebergs, which float down the fjords when the sea-ice melts in late May. The more gentle slopes along the sea and deep into the fjords are the main homes of plants. Here, stony ridges and mounds, marshy hollows, and flat outwashes, all scattered with boulders, stretch from the sea up to the screes and ice of the mountains.

The Rock-Tundra or Barrens

The most open, pebbly ridges, blown clear of snow in winter, are dotted with scattered small tufts of the Purple Saxifrage, very dwarf mats with wine-purple flowers. In these most hard and difficult conditions of the extreme north, exposed to all the dry and bitter winds of winter, with little but gravel to grow on, and watered only by the melting ground-ice and misty showers, *Saxifraga oppositifolia*, the Purple Saxifrage, has few companions. One may find occasional rounded tufts of *Dryas octopetala*, *Polygonum viviparum*, *Draba alpina*, or the frail yellow flowers of *Papaver radicum* (the name for the form of the Iceland Poppy) among the loose stones it favours on inland ridges and the tops of shingle banks above the sea. The pebbles and rocks themselves are patterned with pale yellow lichens, or in moister hollows by dark brown ones.

Further out of the wind, where some snow lies in winter, the Mountain Avens, *Dryas octopetala*, is more common, its dark clumps, often in lines down the furrows, conspicuous among the light coloured stones. With its bushy mats of glossy, wavy-edged leaves, and large white flowers, *Dryas* is both beautiful and hardy. There is no sharp division between these two high arctic communities, the Saxifrage Barrens and the *Dryas* rock-tundra. In the *Dryas* tundra there is a little more soil, a little more protection, but still the uneven rocky land is largely bare. The tussocks of *Dryas* are larger and grow closer together. Among them still grow the hardy Purple Saxifrage, the tight cushions with their yellow blooms of *Draba alpina*, a few *Papaver radicum*, *Polygonum vivip-*

arum, and even the flat-growing dwarf Willow, *Salix polaris*. The little Knotgrass, *Polygonum viviparum*, is one of the arctic plants which produce bulbils instead of flowers on the lower part of its spike as an alternative reproduction for when the short and fickle summer does not allow seed ripening. The watering in the summer as the snow and ground-ice melt enables several sedges and woodrushes (*Carex* and *Luzula*) to grow, their leaves pushed up through the *Dryas* mounds or in frost-yellowed colonies showing where the water seeps.

Dense cushions of the Moss Campion, *Silene acaulis*, can be found, which in the coldest places bloom only on their south sides. The woolly-tufted chickweed, *Cerastium alpinum*, with large white flowers, is adaptable, and grows not only in the windiest barrens all over the Arctic, but also much more luxuriantly in manured grass patches. Scattered in the rock-tundra are the fleshy-leaved *Saxifraga aizoides*, with its yellow, red-mottled stars, the small, round-leaved Alpine Sorrel, *Oxyria digyna*, and various little Crucifers and Sandworts (*Draba* and *Arenaria*), while a white-hoary Lousewort (*Pedicularis*) stands up conspicuously. The sky-blue flowered tufts of *Eritrichium nanum* var. *chamissonis*, a larger form of the prized Alpine plant, are rare, but can be seen here and there, even in the rubbish of the coal mines. All these are dwarf and densely tussocky, blooming quickly in the brief summer, and unharmed even though frozen for the winter in full flower.

These Saxifrage barrens and rock-tundras are the main plant communities of this far northern land, and cover most of the country which is not under permanent snow and ice. They extend up the mountain screes, where the *Papaver* is especially at home, and their plants grow in the crevices of the rocks.

The Heath-Tundra

Away from the sea gales, especially at the fjord-heads on the sides of gullies facing the sun, one may find low heaths. The snow lies deeply but melts early on these slopes. Some humus collects here which holds moisture, so the earth beneath the moss carpet is never dry. The heaths consist of the little clubmoss-like bushlets of *Cassiope tetragona*. They sprawl in the moss and only raise their shoots, with four rows of scale-like leaves, a few inches. They do not produce their white bells if the snow covering is extra deep or melts late. In the extreme north they will grow on limestone with *Dryas*, but are confined to acid peat further south (even in central Norway). The tiny moss-like *C. hypnoides* is very rare in Spitzbergen, at the north of its range, and is found in deep hollows where the snow lies late, in black mud. The ground-hugging Willow, *Salix reticulata*, forms mats of shining, round, furrowed foliage in the warmer parts of the land, its place being taken elsewhere by the dwarfer and much commoner *S. polaris* (allied to *S. herbacea*), which branches and roots in the moss with only its tips in the air. The Mountain Avens (*Dryas*) is frequent in the

heaths, and in open parts, the Purple Saxifrage, the Moss-Campion, and several species of *Draba* and other small Crucifers, with Sandworts and Stitchworts (*Arenaria* and *Stellaria*), form their tufts. *Cerastium alpinum* grows larger than in the barrens, and clumps of Sedges and Woodrushes are common (*Carex* and *Luzula*). The fluffy white spikes of *Polygonum viviparum*, and those of Lousworts (*Pedicularis*), rise above the Cassiopes, and here and there the yellow suns of a Dandelion (*Taraxacum*) can be seen. A tiny Bog-Asphodel (*Tofieldia pusilla*) grows with small Horsetails (*Equisetum*) in damp places. The Fir-Clubmoss (*Lycopodium selago*) never creeps far from the Cassiope bushlets.

Only in the densest parts do these plants succeed in covering all the ground. Here the ptarmigan find their forage in winter, burrowing down through the snow to the berries on the bushes. The Cassiope-heath can only grow in the most kindly situations that Spitzbergen provides. The heath develops best on non-calcareous rocks and is not continuous over large areas. One may come upon a marshy hollow, the sheltered slopes above it clothed by heath, passing up to *Dryas* rock-tundra on the windy tops.

Marshes

Marshes, dotted with shallow pools, cover the flat land, and are filled with hummocks of soggy moss. *Salix polaris* creeps in these moss mounds, sharing their tops with tufts of the Marsh Saxifrage, *Saxifraga hirculus*, with its single large yellow flower to each stem, and the white-clustered *S. stellaris* and *S. caespitosa*. Horsetails (*Equisetum*) are common, including *E. arvense*, the British weed, and various short grasses. Between the mounds and around the pools, beds of the Cotton-grass *Eriophorum scheuchzeri* lift their pure white, silky puffs above the shining black mud, with occasional plants of a small Buttercup (*Ranunculus*). Another Cotton-grass, *Eriophorum angustifolium*, many-headed and beautiful, also colonizes the lines of mud between the stone hill-ocks of the barrens. The pretty little Alpine Foxtail Grass (*Alopecurus alpinus*), with rounded, fluffy spikes, and some low Sedges and Rushes (*Carex*, *Colpodium*, and *Juncus*) form mats on the margins of pools.

Great flocks of sea-birds arrive in May to breed on the cliffs, while eiders, geese and loons make nests on the ground, usually on small islands which the Arctic Fox cannot raid after the sea-ice has broken up. The manuring all these birds give to the soil, especially under the nesting cliffs, entirely alters the vegetation. A thick, deep moss carpet covers the whole area, studded with mounds of yellow and white Saxifrages, Sandworts (*Arenaria*), Buttercups (*Ranunculus*), and tussocks of several grasses.

Salt Communities

Most of the seashores of Spitzbergen are shingle-banks or cliffs, ground by sea-ice and bare, but here and there are estuaries. In the brackish mud nearest the sea grows a band of fine-leaved grass, *Puccinellia (Glyceria) vilfoidea* (very like the common British saltmarsh grass). This is followed landwards by a zone of a salt-enduring Sedge, which merges in its turn into Cotton-grass marsh where the salt no longer reaches.

West Greenland

General Description

Greenland stretches through all the zones of the Arctic. Only a rim along the coast, of mountainous peninsulas and islands, separated by fjords, is free from permanent ice. Yet, though the vast ice-cap of the interior comes so close to the shore in some places that it can be seen from the heads of the bays like a gleaming white line above the cliffs, a rich Mid- and Low Arctic vegetation grows below it along the central and southern coasts. Even in Pearyland, the northernmost land in the world, though most of the country is a stony "barren", the sea-cliffs are coloured red-brown by lichens, a few Iceland Poppies flower on the ridges, and bumblebees visit Dandelions in the small patches of grass where herds of Musk Oxen graze.

Most of west Greenland is of ancient, hard rock, especially gneiss. Along the coast are low, whale-back hillocks ground smooth by ice, behind which rise the mountains above long scree slopes. Every fjord ends at the top in a glacier winding down from the ice-cap, from which break off large icebergs with thunderous roars echoing from the walls of the fjord. Through these fjords the dry powder-snow from the interior swirls in winter, to pile up in drifts in the lowlands, or in widening banks on the sea ice. In the centre of the coast round Disko Island is a stretch of softer rock where the land rises more gently to the mountains behind. Here, torrential cataracts plunge down from the melting snow fields, cutting deep chasms, and laying silty and sandy deltas at their mouths.

The central part of the Greenland coast belongs to the Mid-Arctic zone. The lower land is covered with vegetation wherever even thin soil can collect, which is generally some form of heath-tundra. It is broken by much steep rock almost entirely grown over by lichens, and by mossy bogs and pools in hollows. Higher in the mountains the heath opens and gives way to isolated tussocks, especially of *Dryas*, and rock-barrens.

The southern tip of Greenland, south of latitude 62°, is still too far north for forests, but Birch bushland (of *Betula odorata* or *B. tortuosa*. The naming of a group of related Silver Birches of the far north is confused), as high as a man, can grow on warm hillsides. In the sunniest, most protected valley-heads, a few of the Birches reach the size of a small tree. Grass meadows, luxuriant enough to feed cattle, occupy part of the country, including several new southern plants. The heath-tundra of further north covers rocky mountain slopes, and the High Arctic cushion-plants are found only on inland nunataks in the ice, or on the most windy promontories near the coast. Willow-scrub occupies the wetter and less sunny slopes, where enough snow collects to cover the bushes. The Birches grow close together with several trunks, and are trimmed off to an even height by the wind. The American Rowan appears here and there among the Birches, and the first conifer, the common Juniper, but in its prostrate form, never upright.

Heath-Tundra

The heath-tundra consists of a rather patchy carpet about six inches high. There are usually several different heath shrublets growing together, though one or two are often more abundant than the others. Flowering plants and grasses push up among them. Below, on the peaty soil, is a dense mat of mosses and lichens. The rocks standing above the heath carpet are splashed with black lichen crusts, and in their cracks grow cushions of flowers, small ferns, mosses and frond-forming lichens. The commonest heath-shrubs are *Cassiope tetragona* and *Empetrum nigrum*, the Crowberry. *Cassiope*, typical of the far north, climbs the mountains a little higher and forms a band a little lower in the snow-hollows, while the Crowberry flourishes in the sea fogs. The leaf-losing Bog Whortleberry, *Vaccinium uliginosum* var. *microphyllum*, with its blue-black berries, is to be found everywhere and is specially abundant in some sunnier and drier areas inland, where it joins with the Dwarf Birch to form the main part of the heath-tundra. The Dwarf Birch (*Betula nana*) is absent altogether from some districts. In the windiest places it is a ground-hugging mat, but where more sheltered, it makes a yard-high, finely-twigged bush, with little, round thin leaves. In these drier heaths the mosses are much fewer, and the tall lichens form a pale greyish-ivory carpet among the creeping stems. The Willow, *Salix glauca*, a silvery, silky-leaved low bush, with pink-tipped catkins, grows in damp places in most heaths, and a flat form of the Labrador Tea, *Ledum palustre* var. *decumbens*, is common, though in drier places than the Willow.

Phyllodoce coerulea, resembling a small heather, with clusters of blue-purple bells at the tops of its stems, is scattered generally, but is difficult in cultivation. The dwarf *Rhododendron lapponicum* also has bright purple blooms tending to blue, and is confined to peat over hard gneiss. In open places with thin soil on the same rock, the "Alpine Azaleas", *Loiseleuria procumbens*, spreads flat on the ground. Its pink stars are like those of the Moss-Campion, *Silene acaulis*,

which forms tight mounds in crevices on steep outcrops of rock. The equally dense but woody little domes of the *Diapensia lapponica*, starred with white flowers on short stems, like a Saxifrage, also grow among the lichens in the crevices in company with several true Saxifrages. The firm, silver-edged rosettes of the encrusted *Saxifraga aizoon*, common in many mountain-chains, grow packed together, while *S. tricuspida* forms mats of dark green. Both have sprays of creamy-white flowers. Early colonizers of the lichen mats on the rocks are the Wintergreen, *Pyrola grandiflora*, and the Fir-Clubmoss, *Lycopodium selago*, while two ferns, the Brittle Bladder Fern, *Cystopteris fragilis*, with delicately divided fronds, and the stiffer *Woodsia ilvensis*, both small, are frequently found in crevices on the shady face of the outcrops. The common Harebell of Britain, *Campanula rotundifolia*, and its smaller relative, *C. uniflora*, run in the drier parts of the heath-tundra, with here and there cushions of rosy-pink *Viscaria (Lychnis) alpina*, *Polygonum viviparum*, and the little Alpine Sorrel, *Oxyria digyna*. Short tussocks of Sedge and Woodrush (*Carex* and *Luzula*), as well as several grasses, grow abundantly among the heath-shrublets if water is plentiful. The grasses knit together into vigorous turfs wherever the land is manured and mark the site of settlements for many years afterwards. On sandy soils near the sea the heath is thin and magenta-pin sheets of the low but large-flowered Willow-herb, *Chamaenerium latifolium*, are very conspicuous. Under quite different conditions, in the lee of cliffs, the snowdrifts are deep and melt late, the minute Willow, *Salix herbacea*, creeps underground showing only its tips, and the equally small *Cassiope hypnoides*, like a moss, grows with it. The Willow is typical of the black mud at the bottom of snow-hollows, where the growing time is very short. Where the heath-tundra begins to break up and scatter on the mountain screes, mats of *Dryas integrifolia*, a smaller and lower relative (or variety) of the Mountain Avens, become common in it, with the tight mounds of *Cerastium alpinum*, and other tufty plants of the barrens. As the sun of the long day sets lower in August, these heaths take on the most brilliant autumn scarlets and reds, even though many of their plants hold their leaves all winter. This vivid colouring, appearing even in summer, is characteristic of Arctic plants, especially in the mountains.

Willow-Scrub and Meadow-Tundra

On the sides of the most protected and quiet stream gullies, and in corners under inland bluffs where the snow piles up to some depth, the heath-tundra is sometimes overgrown by grey Willow bushes (*Salix glauca*), to form a scrub a yard or more high. The height of the Willow scrub depends entirely on how deep the snow lies, any twigs left above it in winter are killed by the wind, so the bushes look as if they have been clipped. In the north the heath plants grow among the Willows, and benefit by their shelter, but in the warmer parts of the country, the Willows are often so dense that the ground is nearly bare beneath them. In less shady parts of these Willow scrubs

and around the sheltered edges, flowery and grassy meadow-tundra spreads along the streams and on the banks above.

In the sward of grasses, of which the Smooth-stalked Meadow-grass, *Poa pratensis*, is the most abundant, Dandelions (*Taraxacum*), the Harebells *Campanula rotundifolia* and *C. uniflora*, and Willow-herbs (*Epilobium*), including the handsome *Chamaenerium latifolium*, spread their colour. Pallid insect-catching rosettes of the Common Butterwort, *Pinguicula vulgaris*, are dotted about, and several small orchids (*Habenaria* and *Listera*) raise their slender spikes. An unexpectedly tall and lush plant is the Angelica, *Archangelica officinalis*, which towers amongst the bushes. The large round foliage of a Ladies Mantle (*Alchemilla*) is very conspicuous in some meadows, with colonies of the whitish leaves and black buds of the Cudweed, *Gnaphalium norvegicum*.

Three beautiful small ferns are characteristic of the open meadow-tundra, the Holly Fern, *Aspidium lonchites*, crisp, dark and simply-divided, *Cystopteris fragilis*, and the Oak-Fern, *Dryopteris linneana*, which runs about, uncoiling soft green fronds on slender stems. The Wintergreen, *Pyrola grandiflora*, grows stronger and taller under the Willows than in the open heath-tundra. Tufts of the ferny foliage of the Alpine Meadow-rue, *Thalictrum alpinum*, are to be found, *Polygonum viviparum*, and, hidden in the herbage, the Moonwort, *Botrychium lunaria*.

Moss-Bogs and Pools

Ponds and pools collect in all the hollows over the hard rock, and moss-bogs appear wherever the snow water is held up. The bogs are studded with hummocks and ridges of moss, up to a yard high and wide, with wet channels between. These moss-marshes differ from those of the High Arctic in that the true bog-mosses, cushions of pale brown or red Sphagnum, are to be found among the Cotton-grasses, Sedges and dwarf Willows. In the ponds themselves, which are floored with submerged mosses, one is surprised to find water-plants common all over the temperate regions (*Potamogeton*, *Myriophyllum*, *Callitriche*), and especially the Marestalk, *Hippuris vulgaris*. They cannot often flower, however, and never set seed. The most conspicuous plants of the bogs are the Cotton-grasses, *Eriophorum scheuchzeri* and *E. angustifolium*, their brilliantly white puffs showing everywhere above the dark pools; and the flat grey hummocks of the Willow, *Salix glauca*, growing on the moss mounds. Another Willow, *Salix groenlandica*, much smaller and with red-purple catkins, creeps about in the moss, while several Louseworts (*Pedicularis*) stand above it. A Water-Buttercup (*Ranunculus*) lives in deep water and others along the shallow margins with the Cotton-grasses. The edges of the ponds, just beyond the Cotton-grass, are zoned by a band of tall Sedges (*Carex*), which merges further from the water into one of low

Rushes (*Juncus*) and smaller Sedges. The Rushes are pretty little dark green plants with glossy brown spikelets.

Salt Communities

The shores of Greenland are mostly of hard rock and ground here by the tide-borne sea-ice. But in areas of sandstone there are wide deltas of silt, producing here and there small sand-dunes, held by the handsome blue-grey Sand-grass *Elymus arenarius* var. *villosus*. Behind them may be a little salt-lagoon with a saltmarsh turf of the grass *Glyceria vilfoidea* along the edges. Scattered on the shifting sand near the sea grows *Mertensia maritima*, a lovely plant with grey leaves and sky-blue bells, and the fleshy mats of Sea-Purslane (*Honckenia peploides*).

Russia and West Siberia

General Description

Only the Kanin peninsula and the northeastern-most lands of European Russia, with the islands off the coast, are covered by true Arctic Tundra. But beyond the Paikhoi mountains, the vast plains of the Yamal and Gydanski peninsulas on either side of the Gulf of Ob bear only Tundra. Except for the dome-shaped Paikhoi range, stony and bleak, the land is flat or gently rolling, blanketed by the boulder-clays, gravels and sands of ancient glaciation. Wide areas of tussocky, frost-yellowed Sedge-Tundra stretch across the lowlands. Wherever the land sinks a little, large Cotton-grass bogs fill the hollows, or surround the innumerable puddles and lakes. From these sheets of still water mosquitoes rise in summer in such swarms as to look like clouds of smoke. Here the Bog-mosses (*Sphagnum*) are to be found, though not so commonly as further south. The slopes bounding these marshes are overgrown with low but dense Willow-brush, or if warm, with small meadows of grass and flowers.

The landscape is a wide, slightly undulating plain, endlessly hummocky, interlaced by water-course, pools and ponds, mostly shallow, but some flowing in deep-cut gullies, their banks tussocky with pale Sedges. Between are stretches of dark regular hummocks, sometimes vaguely in ridges down the inclines, and irregular patches of taller Sedges or stunted Willow bushes in low-ways. In areas of sand, the Tundra changes its appearance. The country is ash-coloured for miles with the growth of the shrublet-like fruticose lichens, especially the Reindeer-moss (*Cladonia*), up to nine inches high, like bleached, dried seaweed.

Travelling southward, one finds shrubs of the Dwarf Birch (*Betula nana*) in the valley-side Willow thickets. The Dwarf Birch becomes more numerous, valley after valley, forcing the Willows to the lower, wetter levels. The moss-hillocks of the Tundra become larger, reaching a man's height, and the Birches invade their sides also. These hills are of peat from old bog-moss, forced up by frost expansion, then frozen solid, and never thawing again more than a few inches deep. Thus they gradually grow. The wind keeps their summits clear of snow, drifting it up in the valleys between. Among the stiff, tall, brown-green mosses of the flat tops grow patches of lichens, often closely enough to colour the whole ridge grey. The peat hills become parched at their tops when tall; they crack and crumble and are eroded down again. The small, flat valleys between the peat hills are Sphagnum and Cotton-grass bogs, or open water. The deep snow in the low-ways prevents the land from freezing deeply, and there is no ground-ice in the summer. The lemmings live in these snowdrifts all winter, digging long, winding tunnels to feed on the buried twigs and roots of Willows and Dwarf-Birch.

The Moss and Lichen Tundra

The Moss and Lichen Tundras form a mosaic of dark mosses and pale lichens over the plains, according to the heaviness or sandiness, the dampness or dryness of the aspect. They are the main vegetation of the region, covering even more country than the Sedge and Cotton-grass bogs. The Moss-tundra consists of dense hummocks, a foot high and a yard or more across, of stiff, upright-growing mosses. The tops become dry, but in the channels between, the ground-ice is only at a finger's depth. Their colour is dark brownish-green. Along the wet furrows the Cotton-grass, *Eriophorum angustifolium*, forms lines and beds, while just above it, on the base of the moss-mounds, Sedges (*Carex*) and tufts of grass (*Arctagrostis*, *Calamagrostis*, *Festuca*) grow scattered or in small clumps. Not much of their fresh green is visible among the sheathing of dead foliage. Low sprawling bush-Willows (*Salix glauca*, *S. lanata*) follow the sides of rivulets through the moss, and among them is sometimes found the yellow Violet, *Viola biflora*, and a Golden Saxifrage (*Chrysosplenium tetrandrum*). The Willows shelter plants of a Valerian (*Valeriana capitata*), and the Bistort, *Polygonum bistorta*, much smaller than its lush southern form, but with the same pink, fluffy spikes. Heath-shrublets straggle in the lichen at the top of the mounds, the tiny, evergreen foliage of the Crowberry, *Empetrum nigrum*, like a glossy creeping Thyme; the Cowberry, *Vaccinium vitis-idaea*, also with evergreen, larger, leaves and clusters of pale pink bells followed by red berries; the Bog-Whortleberry, *Vaccinium uliginosum*; and the Black Bearberry, *Arctostaphylos alpina*. The shrublets grow more numerous and conspicuous where the tall lichens predominate, and here also the Dwarf-Birch, *Betula nana*, appears.

Flowering plants become abundant in the moss hummocks on warm slopes where water trickles. Several small, pinnate-leaved Leguminous plants are to be found, with heads of purplish or yellowish pea-flowers (*Astragalus*, *Oxytropis*, *Hedysarum*), as well as the usual *Polygonum viviparum* and *Pedicularis*. The Alpine Meadow-rue, *Thalictrum alpinum*, a small Crucifer (*Parrya*), and a few Composites (*Senecio*, *Saussuria*) add some colour to the monotonous landscape.

Willow-Scrub Tundra

The Willow-scrub grows on wet ground along stream gullies where the snow banks up. In the north it is patchy and very low, of the grey *Salix glauca*, *S. lanata*, *S. lapponum*, and a few others. The Woolly Willow, *Salix lanata*, is a stout, yard-high bush with beautifully silvery silky, rounded leaves. Southward the scrub becomes thicker, and taller species, such as *Salix phylicifolia*, with glossy green foliage, appear in it. The Dwarf-Birch (*Betula nana*) is also often present in the drier, upper parts of the Willow-tundra.

The protection of the Willows and the snowdrifts enables quite large grasses and flowering plants to flourish in south-facing openings. The soil beside the streams is silty and well-watered, and green meadows of grasses (*Calamagrostis*) and Sedges (*Carex*) develop here and there. Meadow-sweet, *Filipendula ulmaria*, a Jacob's Ladder (*Polemonium acutifolium*), Bistort (*Polygonum bistorta*) and the wild Golden-rod, *Solidago virgaurea*, with handsome heads of yellow, but not so ample and arching as the garden plants, all grow here. Below them can be found the single, pure white blooms of the Grass-of-Parnassus, *Parnassia palustris*, and the little creeping Arctic Bramble, *Rubus arcticus*, with its large rose-pink flowers. Most beautiful is the blue of *Delphinium elatum*, one of the parents of the garden Delphiniums.

Wherever the drainage is held up, Sphagnum and Cotton-grass bogs appear, and in west Siberia, they are nearly universal in the gaps among the Willows.

Dwarf-Birch Scrub Tundra

Thickets of the Dwarf-Birch (*Betula nana*), knee-high or taller, cover wide stretches of warm slopes in the south. The thickets are a tangle of tiers of thin twigs and small leaves, sometimes so dense that little else can grow. The Birches grow either short single trunks, or more often several, like a bush. They penetrate into the Willow-scrub, but higher up the slopes the Willows and most of the mosses disappear, and lichens cover the ground with a dry grey carpet. Here the Black Bearberry, *Arctous alpina*, the Alpine Azalea, *Loiseleuria procumbens*, the Cowberry, *Vaccinium vitis-idaea*, Marsh Tea, *Ledum palustre*, and fine-leaved grasses and Sedges are scattered among the

lichens in open places between the bushes. *Ledum palustre* is a low, thin shrub with small and narrow evergreen leaves and heads of white flowers.

Often in Siberia the Birch thickets, mixed with Willows, stand on slight elevations above wet channels in which grow colonies of Sedges and water-loving grasses. The Dwarf-Birch scrub also flourishes on peat, and grows to a yard high on the sides of the peat hillocks of Russia where sheltered, but is reduced to creeping in the moss at their summits.

Central Siberia

General Description

In the central region of the Siberian Arctic, from the Taimyr peninsula eastward, the desiccating cold of the winter winds is more severe than in Spitzbergen, far to the north. The summers, on the other hand, are warmer, occasionally reaching 80°F, and are less foggy. The climate is the most “continental” of the whole Tundra region, and the driest. Several areas are underlain by hard rock, the country is more hilly than west Siberia, and less covered by glacial drift.

The mouths of the great rivers, the Yenesei and the Lena, thaw in early June, bringing down rafts of ice and much driftwood from the forests of the south. With the thaw the low-land becomes flooded and gleaming with shallow pools and puddles, or treacherously boggy over the permafrost. When the huge flocks of water-birds arrive to nest, the long winter silence breaks with overwhelming excitement by day and night. As the water runs off and the sun gains power, the surface of the land dries and becomes parched, but cold damp soil and the ground-ice is only just below.

The vast peninsula of Taimyr, reaching to the northernmost mainland of Asia, Cape Chelyuskin, is a great rolling tundra plateau, broken by the barren and stony Byrranga mountains, rising to three thousand feet. North of these mountains, along the Arctic Ocean, Cotton-grass bogs, with Sphagnum and some peat-formation, alternate with stony lichen and moss tracts, on which *Dryas*, Cowberry, a flat species of *Ledum*, and Dwarf-Birch mingle with small Sedge tussocks.

South and east of the Byrranga stretches mile upon mile of a rather arid patchwork of Moss and Lichen Tundra. The moss hummocks do not rise above six inches and show much bare ground between them.

Dwarf Willows and heath-shrublets, together with small Sedges and rounded cushion-plants, wrapped in their dead leaves, are hardly visible on the moss mounds, while water-loving Saxifrages and a single-headed Cotton-grass grow near their base.

The Moss-Tundra

The moss-tundra, like that of the west, is a mosaic of moss hummocks with wind-seared and lichen-matted tops, but the mounds are lower, flatter and with sometimes only half the ground covered. The whole Tundra is more stunted by the greater cold and drought than further west. *Cassiope tetragona* and *Dryas punctata*, plants of the far north, are the main shrublets, half-buried on the moss-hummocks. The Willows are flat-growing ones, including *Salix reticulata*. Almost ball-shaped mounds and cushions of mauve Milkvetches (*Astragalus*), yellow Composites (*Senecio*, *Crepis*), *Polygonum viviparum*, and the Iceland Poppy, *Papaver radicum*, all very small, flower here and there so profusely that their foliage is hidden. Sandworts (*Minuartia*), looking like mosses themselves, are covered with white stars, while a dwarf Forgetmenot (*Myosotis asiatica*) and the beautiful *Eritrichium villosum* are mounds of vivid sky-blue. A small Purslane (*Claytonia arctica*) can be found, the nearest relatives of which are American. Growing on the edges of the furrows are the Saxifrages *Saxifraga punctata*, *S. cernua*, *S. hirculus*, with tussocks of the Cotton-grass *Eriophorum vaginatum* and the grass *Arctagrostis*. Everywhere, emerging through the moss, are the thin ribbons, already withering, of the Sedge *Carex hyperborea*, which produces its dark spikelets first in the season.

Endless distances of this yellow-brown Moss-Tundra, netted with furrows of bare gravelly clay, stretch up and down the hills as far as one can see, and cover most of the country.

The Lichen-Heath Tundra

Where the soil is rocky or sandy, and watered by melting snow-banks, the dwarf-shrubs grow more vigorously. The low hummocks of *Dryas* (*Dryas punctata*) interlace, and *Cassiope tetragona* forms dark mounds in depressions. The mosses nearly disappear and their place is taken by scattered tall lichens. Sedges and grasses make a thin and wispy upper layer, while the flowering stems of *Novosieversia glacialis* (a yellow-bloomed relative of the Geum) push up conspicuously.

The *Dryas*-heath never covers all the soil, even where the shrublets are at their densest. Away from the water, the hummocks thin out, and between them only lichens, or the mats of the Purple Saxifrage (*Saxifraga oppositifolia*) and of *Diapensia lapponica*, or the close domes of several spe-

cies of *Draba* and *Minuartia* dot the gravel. Here also can be found the plump, hairy rosettes of *Androsace triflora* (related to *A. chamaejasme*), and the Saxifrages *Saxifraga bronchialis*, *S. cernua*, *S. nivalis* and *S. flagellaris*, all mossy-leaved mats with white, pale yellow or deep gold blooms.

The only areas of brighter green are patches manured by seasonal floods, or by animals and man, where grasses can form a closed turf. On some south-facing streambanks, though the plants do not cover all the silty black soil, small flower meadows can be found.

Among the Milkvetches (*Oxytropis*), the Dandelions (*Taraxacum*), the Forgetmenots (*Myosotis*), the Buttercups (*Ranunculus*), including *R. pygmaeus* and *R. nivalis*, and the Saxifrages (*Saxifraga*), show the blue and yellow flowers of the dwarf *Delphinium humile*, only an inch or so tall above its wool-covered, feathery foliage. The glistening gold flowers of the Kingcup (*Caltha palustris arctica*) open at the edge of the water, with the pink spikes of the Bistort *Polygonum bistorta*.

Far Eastern Siberia

General Description

Eastward from the River Indigirka the climate changes and the influence of the Pacific Ocean and its arms, surrounding the peninsulas of eastern Siberia, softens the extremes of temperature, and brings a little more rain. But the weather is always cold and raw. A current carrying blocks and islands of the Polar ice flows through Bering Strait from the Arctic Ocean, cooling the seas to the south, and there are no warm currents. The winters are clear, windy and frozen, and the blizzards do not bring much snow. The summers are foggy and bleak with driving rain.

East of the River Kolyma the country becomes mountainous, with the Chukotski ranges in their wild tangle of ice-carved ridges and ravines, facing the Arctic Ocean and reaching Cape Dezhneva at the far eastern tip of Asia. Where the rock is hard and forms cliffs, the slopes below are blanketed by the enormous screes characteristic of Arctic mountains. The fragments of rock, splitting from the outcrops above, freeze together where they fall. Only where the sun strikes directly do they thaw, so the scree grows. The water from this shallow thawing rushes down, cutting deep channels through the ice and stones.

In the flatter areas in the valleys and on the lower slopes, a hummocky Tundra extends, consisting of Cotton-grass tussocks, with Dwarf-Birches and low heath-scrubs growing at their base in a car-

pet of mosses and lichens. This type of Tundra, intersected by Sedge-marshes and open water, also covers much of Alaska across the Bering Strait, and is peculiar to these two areas. But most of the country is highland. Above 350 feet (110m.) in the north, higher in the south, the growing season becomes very brief. The lowland Birches disappear and *Dryas* takes their place, with lichen undergrowth, dense and nearly closed where sheltered and well-watered, but thinning to scattered lines and tufts among the stones on exposed ridges. Mountain Moss-Tundra with Sedges and grasses develops at the bottom of hollows or where water seeps. At greater heights the snow lies in patches, some permanent, among the crags, screes, and stony wastes, but does not collect in large enough depths to form glaciers.

The Mountain Tundra

The scree and rubble slopes in the mountains bear a different type of tundra from that of the lowlands. Mounds of *Dryas punctata* (or *D. octopetala sub sp. punctata*) spread among the stones, usually in the furrows, though becoming nearly closed on well-watered terraces. A few other Heath-shrubs, including the Black Bearberry (*Arctous alpina*) grow scattered among the *Dryas*. *Cassiope ericoides*, with its white bells on dwarf, heather-like bushlets, is common where the snow drifts. *Rhododendron kamtschaticum*, very dwarf, leaf-losing, and with wine-purple flowers, forms low mounds, with the silky, filigree mats of *Artemisia glomerata*, the tight cushions of Sandworts (*Minuartia*), of Milkbvetch (*Oxytropis*), and the rosettes of *Arnica frigida*, with its yellow suns. The ferny mats of *Selaginella sibirica* creep among the shrublets like large feather-mosses.

Sedges (*Carex*, *Cobresia*) grow in beds showing where water and mud collect, and here also mosses spread freely. The little Parsley-like foliage and brown tassels of *Thalictrum alpinum* grow in the moss, with small Chickweeds (*Cerastium*) and Stitchwort (*Stellaria*), and the yellow bloomed *Senecio resedifolius*. *Gentiana algida* sprawls and lifts its deep blue trumpets. By snow-fed stream-sides in protected ravines, the Tundra becomes more green and flowery. The grass *Festuca altaica* is abundant, the Globe-flower, *Trollius riederiana*, holds its polished golden open blooms, *Mertensia kamczatica* sprawls and has crosiers of clear light blue, *Primula cuneifolia* raises pink blooms from leathery rosettes. Below are the tufts of a little Grass-of-Parnassus, *Parnassia kotzebuei*. A Windflower, *Anemone sibirica*, and a Goatsbeard, *Aruncus kamtschaticus*, grow near the water.

Dry, windy, stony ridges rise above. Here the *Dryas* mounds become flat, or pushed downhill into lines by frost movement, and their companion plants, reduced to tiny cushions, are lost in the furrows among the stones. Small tufts of moss inhabit crevices, and patches of lichen encrust the boulders and rock-faces.

Alaska

General Description

Low-Arctic Tundra covers the northern coastlands of Alaska. The country rises from the northern plains to the Brooks Range of seven to eight thousand feet in gently rolling terraces cut by flat-bottomed valleys. The west coast, exposed to gales off the cold Bering Sea, is also Tundra-covered, except in sheltered bays south of the Arctic Circle, where the forest reaches to within a mile of the shore. North Alaska has a climate of continental character, very dry, very cold in winter, and hot for short periods in summer. There are frosty days in every single month, and continuous frost from October to May. The west coast as far south as the Alaska Peninsula, which cuts off the warmer Pacific influence, is still severe.

As in other Arctic lands the vegetation is a low patchwork which repeats itself over the land according to aspect of slope, drainage, and frost and thaw action over the permanently frozen subsoil. The landscape is one of mounds and hummocks, ponds, lakes, and marshes. Pale yellow-green tussocky patches of Cotton-grass, becoming shining white with their fluff in summer, dark hummocks of brown-green dwarf-shrubs often overgrown on their tops by ivory-coloured lichens, spongy mats of Bog-moss in the furrows between, interspersed by Sedge-marshes, alternate over miles and miles.

Willow-scrub and Alder-brush grow along streamsides, becoming quite tall towards the south. The Tussock-Tundra and the brighter green Sedge-marshes give way in the hills to various forms of Heath-Tundra. Dwarf-Birch predominates on dry gravelly slopes at low elevations. Higher, other heath-shrublets, more resistant to wind, take its place, and in turn, are superseded on the mountains by *Dryas*. On the summits and crests, only lichens encrust the rock, while mosses and taller lichens and a scattering of tiny plants find shelter in trenches down the frozen scree and between the snowfields. In the north, *Dryas*-heath also occupies frost-heaved areas, growing between the bare heaps of rock and soil pushed up. Where the land is low-lying and wet however, dwarf Willows are the main plants in the furrows.

Cotton-grass Tussock-Tundra

The Cotton-grass, *Eriophorum (vaginatum) spissum*, is a tufted, grass-like plant with narrow foliage and balls of shining white cotton when in seed. These are so numerous that acres of white spread across the hills and lowlands in their season. They can grow on drier ground than other

Cotton-grasses. The plants build hummocks of their old foliage a foot or so high and more wide, from the sides of which the Dwarf-Birch *Betula nana exilis*, the Cowberry or Mountain Cranberry *Vaccinium vitis-idaea*, the Crowberry *Empetrum nigrum*, and *Ledum decumbens* grow to form mounds of their own. In some areas they are more abundant than the Cotton-grass and colour the landscape. Other heath-shrubs are less common, the Mountain Bearberry, the Bog Whortleberry or Blueberry *Vaccinium uliginosum*, and dwarf Willows. In the north, *Dryas integrifolia*, *Cassiope tetragona*, and *Rhododendron lapponicum* are to be found in the Tussock-Tundra, but in the south are more common in the mountains. Two peat-loving shrublets, the Cloudberry, *Rubus chamaemorus*, and *Andromeda polifolia*, occasional in the Tussock-Tundra of the north, are also more abundant along the west coast where peat-formation is greater. Sedge and grass tufts stand among the dwarf-shrubs everywhere. The Sedges (*Carex*) are the predominant plant along the shallow drainage channels and flats, among mounds of moss and shrublets. Grasses (mainly *Arctagrostis*) become common in drier places. Lichens colour all dry prominences grey, and mosses (including Sphagnum) fill the damp gaps between tussocks with a hummocky carpet several inches deep. Flowers are not very numerous or conspicuous. The pink spikes of the Bistort (*Polygonum bistorta plumosum*) are to be seen in many places, with several Louseworts (*Pedicularis*), and low, finger-leafed clumps of the most northerly Lupin, *Lupinus arcticus*. Rich yellow Arnicas (*Arnica lessengii*), a reddish single-flowered Anemone (*Anemone richardsonii*), and the small blue Jacob's Ladder, *Polemonium acutiflorum*, are scattered. The Wintergreen *Pyrola grandiflora* sends up spikes of waxy cream blooms from the shelter of the dwarf-shrubs. A Butterbur, *Petasites frigidus*, and Lady's Smocks, *Cardamine richardsonii*, run in the wet channels with the Sedges. *Saxifraga punctata* and the tiny *Parnassia kotzebuei* creep about below.

Alder and Willow Tundra

Areas of bush and scrub, mainly along streams, vary the monotony of the Tussock-Tundra with patches of dark or paler green. Low bushland of the dark green Alder, *Alnus crispa*, grows on well-drained valley-sides. It is only a man's height in the north, where it is confined to south-facing aspects in sheltered ravines. It is often so dense that there are few plants beneath the bushes. Shrub-Willows occasionally join the Alders, but only in damp places. In openings the purple plumes of the grass *Calamagrostis canadensis* are common, growing in a moss carpet, with Horsetails (*Equisetum*), the Rosebay Willowherb or Fireweed, *Chamaenerium angustifolium*, and the shrubby *Spiraea beuverdiana*. A few plants of Blueberry straggle here and there, but the Wintergreen *Pyrola grandiflora*, the creeping dwarf Cornel, *Cornus suecica*, with its cross of white bracts and red berries, and the Clubmoss *Lycopodium annotinum* flourish in the shelter.

Willow-scrub grows along streamsides in the north, where the main Willow is *Salix glauca*. Among the bushes the Bog-mosses form mounds, on which the Cloudberry, *Rubus chamaemorus*, creeps, conspicuous in late summer when its flesh-pink berries are ripe among comparatively large foliage changing to orange-red. In the furrows the Butterbur *Petasites frigidus* is common among the Sedges. A Stitchwort (*Stellaria*) and *Saxifraga cernua* show their white stars. Further south the Willows grow taller. The gravelly banks of the streams bear a zone of felty-leaved Willows (especially *Salix alaxensis*), up to fifteen feet tall, while a shorter bushland of green-leaved ones occupies wet land everywhere. The ground is hummocky with mosses. In openings and gaps among the bushes grow some of the heath-shrublets, with various grasses, the blue-green, leafy *Mertensia paniculata*, unrolling sprays of purple and clear blue, and *Anemone narcissiflora*, with its beautiful heads of white and rose. Depressions through which the water flows are flowery. The twiggy bushes of *Potentilla fruticosa* covered with small yellow blooms, the narrow-leaved, dull green shrublets of *Andromeda polifolia* hanging pink and white bells, the Roseroot, *Sedum roseum*, with its thick, trunk-like stocks bearing fleshy grey leaves and heads of pale yellow, the small fern *Woodsia glabella*, *Polemonium acutiflorum*, and the grey waxy foliage and purple flowers of the Fumitory *Corydalis pauciflora*, are all to be found.

Sedge marshes

The land is netted with waterways, pools, and low-lying marshy areas. On gently sloping terraces in the north, wide flat-bottomed channels in the Tussock-Tundra are filled with beds of Sedge (*Carex*), through which the water trickles in many small runnels. Among the Sedges grow clumps of *Hedysarum alpinum americanum*, Stitchworts (*Stellaria*), and *Saxifraga cernua*. The many-headed Cotton-grass, *Eriophorum angustifolium*, and the Kingcup, *Caltha palustris arctica*, are abundant in the black mud. Submerged plants grow in ponds where the water is still, the white Water-Buttercup, *Ranunculus aquatilis*, the Pondweeds (*Potamogeton*), and the Maretail *Hippuris vulgaris*. On the edge is the large-flowered Buttercup *Ranunculus pallasii*. Spreading round the ponds and lakes on low-lying flat land are peaty Sedge-marshes with many flowering plants, studded with hummocks, and with a ground layer of mosses, including Sphagnum. Bush-willows of several sorts, *Potentilla fruticosa*, and *Andromeda polifolia* are woody plants scattered here and there on the hummocks, where grasses (*Arctagrostis*, *Calamagrostis*) are common. The golden marsh Saxifrage (*Saxifraga hirculus*), the low but large-flowered Shooting-star *Dodecatheon frigidum*, the Alpine Meadow-rue *Thalictrum alpinum*, the little *Gentiana glauca* with single blue trumpets, the lilac bloomed *Iris setosa*, and the Bistort, with a number of Louseworts (*Pedicularis*), are all small plants on the mounds or hidden in the Sedges. Near the edge of the forest Sphagnum grows more freely and deeper peat forms, often in ridges down the slope, alternating with Sedge-

marsh in the troughs. The Cloudberry (*Rubus chamaemorus*) shares predominance on these ridges with other dwarf heath-shrubs and lichens.

Heath Tundra

The Tussock-Tundra gives place on the steep slopes of the hills and in the mountains to Heath-Tundra of various types. Scrub of Dwarf-Birch, *Betula nana exilis*, hardly a foot high, scattered in a thick mat of lichens, occupies the lower slopes of the hills on dry gravel and rubble from which the snow melts early. With it spread mounds of the pink-starred Alpine Azalea, *Loiseleuria procumbens*, and, less abundantly, the other heath-shrublets. If the ground is fairly well-watered, several dwarf Willows grow with it also. Fine-leaved grasses (*Hierochloe*, *Festuca*, *Poa*) are usually present, but part of the land is altogether bare of plants. On colder and more snowy sites, and higher in the hills, the Dwarf-Birch becomes stunted and rare, and the Blueberry (*Vaccinium uliginosum*), or the Mountain Bearberry supplants it as the main sub-shrub. Where the snow is later still in melting, *Cassiope tetragona* takes predominance, and in deep hollows, is the only dwarf-shrub. Here the melting snow waters the ground late into the summer, and the soil is cold. In the foot-hills dark green Cassiope hollows may lie between ridges occupied by Dwarf-Birch and pale lichen, while tall Willow-bush follows the brook-sides. The soil in these well-watered Cassiope-Blueberry heaths is completely covered by plants. Mosses take the place of lichens, which are sparse. In addition to the Bistort, Sedges and small Horsetails (*Equisetum*) which are fairly common among the shrublets, a Shooting-star *Dodecatheon macrocarpum*, tufts of the pinnate-leaves and pea-flowers of *Hedysarum alpinum americanum*, the pale pink heads of *Valeriana capitata*, and the bloom-clusters of *Anemone narcissiflora* show here and there. Plants of the far north can be found in these areas of short growing season, and the mounds and mats of *Dryas* and *Salix reticulata* are common, with tufts of *Polygonum viviparum*, the Iceland Poppy (*Papaver radicum*), and the ferny clumps of *Polemonium pulcherrimum*, with its large blue cups. Small streamside meadows run through the scrub. Here the dwarf-shrubs are few, except for *Rhododendron kamtschaticum* and dwarf Willows, and the flowers and grass (especially *Festuca altaica*) are more luxuriant. The Roseroot (*Sedum roseum*) grows here with the yellow *Viola biflora* and *V. langsдорffii*.

Mountain Tundra

The mountain Tundra, as in many Arctic ranges, is predominantly of Mountain Avens (*Dryas*). There are several closely related species (or races) of *Dryas*, sometimes grouped together as *Dryas octopetala*, which in its typical form prefers calcareous soil. The *Dryas* Tundra contains other

species of dwarf-shrubs and herbs, which may grow in colonies showing as patches of darker or brighter colour among the grey-green of the *Dryas*, or may be scattered singly. Darker strips meandering down valleys through the Tundra, or spreading out in the basins, show where water runs, and where *Cassiope tetragona*, dwarf Willows (*Salix chamissonis*, *S. reticulata*), Sedges, Wood-rushes (*Luzula*), and grasses (*Hierochloe*, *Poa arctica*) grow luxuriantly. Here more soil accumulates among the rocks and Mosses form low hummocks, on which are feathery-leaved tufts of Milkvetches (*Oxytropis*). The ground elsewhere is stony, with rocks encrusted with lichens showing among the plants. The wind blows almost continuously over these high slopes and ridges, allowing little snow to lie. Mosses and lichens grow everywhere, but they are short.

Among the *Dryas* are shrublets of *Ledum decumbens*, the Crowberry, the Mountain Cranberry, *Diapensia lapponica*, *Rhododendron kamtschaticum*, and, most abundantly, *Loiseleuria procumbens*. The large single bells of *Campanula lasiocarpa* stand upright over its tufts of green foliage, among the silver-grey mats of *Antennaria isolepis*, and low mounds of *Artemisia arctica*, . The little greenish flowered "Scottish Asphodel", *Tofieldia pusilla*, creeps in the gravel. Steep rocky slides and buttresses rise from the Tundra to the ridges and summits. They are usually rounded to whaleback shape by ice. The Tundra creeps up gullies between the expanses of grey rock, patched with crusts of lichen, and ends as tiny tufts of moss and a few dwarf plants at their heads, sheltered in hollows among the stones. Gleaming snowdrifts lie all summer in the *Dryas* Tundra under the lee of north-facing cliffs.

The Forest-Tundra and Subarctic Transition Region

The Forest-Tundra Transition Region

General Description

The subarctic zone of tension between the Tundra and the Boreal Coniferous Forest varies in its width, its character, and its constituent communities round the world.

In flat continental lands the Tundra merges, often through scrubland, into scattered open woods, then closed forest. Many Tundra communities continue among the widely-spaced trees, and in the open areas between their stands. Sometimes the trees are wind-flattened tables, sometimes upright, but small and thin, like young saplings, though very old. Often they are bearded and grey with lichens.

In mountainous country, Tundra, or Tundra-like communities, extend right through the zone, and far beyond, on the windy, cold heights, while the outliers of the forest are confined to the sheltered valleys, rising gradually higher up the slopes towards the south.

On oceanic islands and coastal lands in the transition region, such as Iceland, the Aleutians, the southern tip both of Greenland and Kamchatka, whilst the highlands bear Tundra, there are no coniferous forests on the lowlands. A subarctic vegetation of willow-, alder-, and birch-scrub, with meadows, marshes and bogs takes their place. This is perhaps because of the high sea gales in all seasons.

The Forest-Tundra of Europe

Northern Norway and the Kola peninsula is a plateau of hard, ancient gneisses and granites, rising from six to seven hundred feet in the east to a higher tableland in the west, where it is broken by the valleys of torrents and cut by deep fjords. Mainland Russia, east of the White Sea to the Urals is lower and flatter. The whole country, except where the mountain rocks rise from it, is mantled by glacial clay and sand.

The Coniferous Forest reaches the ocean only along the shores of the White Sea. On the western plateau peninsulas the most northerly Coniferous Forests are of the Common Pine (*Pinus silvestris*), on mainly sandy and rocky soil, with a wide fringe of Birchwoods to the north of them. Eastward, on the Russian plains, the Spruces (*Picea abies* and *P. obovata*) are the first to appear, often with Birches also.

In Norwegian and Russian Lapland, the narrow ravines shelter the most northern woods of a Silver-Birch, which grow quite tall, and reach the salt water along fjord-sides in the west. They spread up the slopes, becoming more and more scattered, to a tree-limit at about 900 feet. Along the valleys, which are mostly floored with glacial sand, stretches mile upon mile of these light, open Birchwoods, the white trunks standing wide apart over a pale lichen carpet, varied by patches of dark shrublets. Above them rise the uplands and higher ranges, bare of trees. The Pine first appears in the Birchwoods not far south of the shore of the ocean along the warmest ravine-sides. Eventually, travelling southward, Pinewoods occupy all the valleys of the interior, with a zone of Birch on the mountainside above them. Higher still on the mountains, Heath-Tundra extends, of the same subshrubs as in the Birchwoods, but dwarfed by exposure. They reach nearly to the peak ridges, and stretch over the rolling plateau to the horizon, varied only by outcrops of rock or the gleam of water. The highest summits themselves bear only Mountain-Tundra. They are most-

ly bare rock and boulders, encrusted here and there with lichens, and with a few little tufted or creeping plants half-hidden in the crevices, or pressed flat on the ground.

The Murman coast and that of the Russian mainland south of the true Tundra is a treeless, subarctic country, with much Willow-brush and Dwarf-Birch scrub on peaty ground. The land is studded with lakes and bogs, in which Sphagnum moss plays a more important part than further north. The Moss-Tundra, with greater accumulation of peat, becomes Peat-hillock Tundra, with Sphagnum-bogs between the mounds. Lichen and Heath-Tundra occupies sandy and stony land, and on these well-drained Lichen heaths, mainly along the valley-sides of the large rivers, the first forest trees are to be found. They are widely-spaced, small Spruces, with a scattering of Birch, often with their tops dead after an extra severe winter. In exposed places the Spruces may be reduced to flat mounds, rooting where their branches lie on the ground, all summer shoots being killed if they rise above the winter snow level. Strips and patches of Meadow also can be found among the Willow-bush and trees along the river and brook banks, with lush grass and tall flowering herbs.

The Birch Woods of The West

At their northern limit, the Birches (*Betula odorata*) stand close together only in the narrow valleys; on the drier slopes the slim trees are scattered over the hillsides singly. Here and there a Rowan (*Sorbus aucuparia*), red with berries in the autumn, grows with them, and occasionally a dark Juniper (*Juniperus communis*). Immediately under the trees, and in the copses, ground plants grow thickly; the Crowberry, the Cowberry, and the Bog-whortleberry mat and tangle, run through by the creeping *Cornus suecica*, and the leaf-losing Bilberry (*Vaccinium myrtillus*), with its solitary blue-black berries. *Phyllodoce coerulea* shows clusters of large bells, and the flat evergreen mounds of the Red Bearberry, *Arctostaphylos uva-ursi*, droops its pink ones. Among the heath-shrubs are beds of the lush, cut foliage and golden, half-closed cups of the Globeflower (*Trollius europaeus*), the Goldenrod, *Solidago virgaurea*, with the mauve Cranesbill, *Geranium silvaticum*, rusty-red Sorrel (*Rumex acetosa*), and Cow-wheat (*Melampyrum*). The fine leaves and purple plumes of the Wavy Hair-grass, *Deschampsia flexuosa*, are common, and mats of the little Bramble, *Rubus arcticus*, and the Interrupted Clubmoss, *Lycopodium annotinum*. The Oak-fern (*Dryopteris linnaeana*) runs in the shade, with the graceful Wood Horsetail (*Equisetum silvaticum*).

Outliers of the Pine forests are the Twinflower, *Linnaea borealis*, *Trientalis europaea*, and the Wintergreen, *Pyrola (Ramischia) secunda*. Here and there are showy stands of the Rosebay Willow-herb, *Chamaenerium (Epilobium) angustifolium*.

Around these patches of green under the trees, wide, pale lichen-covered areas, littered with stones and boulders, give the woods a dry, sparse appearance. Stretches of open moss and lichen Tundra interrupt the woods here and there on the flat valley-bottoms. Where water flows the bush-Willows, *Salix glauca* and the silvery *S. lanata* are abundant, with the Buttercup, *Ranunculus acer*, and *Polygonum viviparum* between them. The Cotton-grass, *Eriophorum vaginatum*, grows on Sphagnum-moss in hollows, with *Parnassia palustris*, the Cloudberry, *Rubus chamaemorus*, the drooping, dusky-pink Water-Avens, *Geum rivale*, and the Marsh Cinquefoil, *Comarum palustre*.

It is in these Birchwoods that the first outlying Pines of the Coniferous forest appear.

Mountain Heath-Tundra

Above the Birch woods, which thin out gradually and become more scrubby, until they finally disappear, the areas of lichen and rubble increase over the plateau. The Dwarf-Birch and the Crowberry are the main dwarf-shrubs, with Bilberry creeping everywhere. Most of the other heath-shrubs and flowering plants of the open hillside Birch woods can be found also, but less abundantly. The dwarf Willows, *Andromeda polifolia*, and the Cloudberry are common in damp peaty places. Unexpectedly, in this harsh environment, one comes upon steep rubble slopes covered by the delicately divided fronds of the Lady Fern, *Athyrium filix-femina*, usually intermixed with Sorrel.

The heath-Tundra is monotonous, duller green and grey, but slightly varied by many hollows, into which the snow drifts, and where the vegetation grows much taller. At the bottom of the deeper ones, under snow till very late, the wet soil remains largely bare but for mosses, the tiny Willow *Salix herbacea*, the cottony-leaved Cudweed, I, a little Buttercup, *Ranunculus pygmaeus*, and the Mountain Sorrel, *Oxyria digyna*.

Mountain-Summit Tundra

The summits are rubble and ice-rounded rock, partially encrusted with lichens. From cracks, completely prostrate mats of Dwarf-Birch, Crowberry, Bog-Whortleberry and Black Bearberry spread onto the rock. Wind-flattened mounds of *Dryas octopetala*, *Diapensia alpina*, *Phyllodoce coerulea* and *Loiseleuria procumbens* are also to be found. Cushions of the Moss-Campion, *Silene acaulis*, and the Butterwort, *Pinguicula alpina*, grow in crevices.

The Forest-Tundra of Siberia

General Description

All across western and central Siberia the trees of the Forest-Tundra are Larches. On the plains of west Siberia they are Siberian Larches (*Larix sibirica*), growing here and there on raised terraces and banks along the rivers, or on peat ridges with Dwarf-Birch, and with Sphagnum-bogs in the hollows between.

Sometimes a few trees of the northern Silver-Birch (*Betula tortuosa*) accompany the larches, or patches of dwarf Alder. Siberian Larches also line sheltered valley-sides among the foothills of the Urals, with Silver-Birch forming a zone above them. The open country is covered by Dwarf-Birch and lichen Tundra, or Willow scrub, netted with large areas of bog and water. Meadows of lush grasses and flowering herbs occupy the flood-plains of the large rivers which bring down much ice in the spring thaw.

On the plateau of central Siberia, the Daurian Larch (*Larix dahurica*) takes the place of the Siberian larch near the River Pyasina, east of the Yenesei, and stretches on to the River Kolyma, beyond which it peters out in the mountains. It can survive the drier, more extreme climate better than the Siberian Larch. The lichen-covered little trees, thin-trunked though old, stand in their scattered copses, or singly, among the bush-Willow and Dwarf-Birch Tundra along the warm and better-drained banks of the rivers, where the permafrost is deeper in the ground. As in the west, the soil below them is deep in tall grey lichens and moss, through which straggle wiry Heath-Tundra shrubs.

The Forest-Tundra is a wide zone of very sparsely and patchily wooded country along the northern foot of the tablelands. Unlike west Siberia, there is little Sphagnum-bog, as the climate is too dry. Little meadows are to be found, however, along river plains, sheltered by the Willow-bush. The Forest-Tundra merges directly into the true Coniferous Forest, or Taiga, over all the western plains, but only along the valleys of the large rivers in the east. From the Yenesei eastward, ranges of mountains separate them, too high and bleak for trees. The highlands rise in stony, windy slopes, covered only by Heath and Rock Tundra. Dwarf-Birch and Willow thickets along the torrents in the ravines are the most luxuriant growth. In the vast region of the Putorana ranges, the

Forest-Tundra is cut off from the Taiga by hundreds of miles of treeless mountains, rocky and forbidding.

West and Central Siberia

Larch Forest-Tundra

In the west of Siberia the low trees of Siberian Larch stand along the sides of sandy ridges thrown up by the streams. Occasionally a stunted Siberian Spruce (*Picea obovata*), even smaller than the Larches, grows in their shelter near the water. The northern Silver Birch (*Betula tortuosa*) borders the copses here and there. The heath-shrublets of the Tundra spread vigorously below the Larches, and cover the wide gaps between, the Crowberry, the red-berried Cowberry, the Black Bearberry and *Ledum palustre*, with areas of tall lichens, also favoured by the protection. On the warmest slopes the Dwarf-Birch (*Betula nana*), and the bushy Alder (*Alnus fruticosa*) form thickets, in the openings among which grow the Bistort, the Wood Horsetail, and *Valeriana capitata*. The Siberian Larch also grows on the sides of the peat-hillocks in the bogs, which cover much of the land, accompanied by the Dwarf-Birch. Here the Bog-Whortleberry and *Andromeda polifolia* become common, while the Cranberry, *Oxycoccus (Vaccinium) palustris*, with its Nightshade-like, pink flowers and red berries, extends its wiry stems through the wet moss in hollows, among beds of Sedge.

East of the Yenesei the plateau country starts. Leaving the open Tundra and entering from the north the foothills leading up to the plateau, the low Willow scrub along the stream-sides grows taller and denser. *Salix phylicifolia* and *S. hastata* join the lower Willows; and together with thickets of the eastern Dwarf-Birch (*Betula exilis*) and of the Alder (*Alnus fruticosa*) growing a little higher up the hillsides. Bushlands cover more of the country than in the north. Where the drainage is bad, Cotton-grasses spread, and the wild Redcurrant (*Ribes rubrum*) grows on low hummocks of Sphagnum. The well-drained or stony slopes are grey with lichens, in which creep the heath-shrubs, the Cowberry, the Crowberry, *Ledum palustre*, and *Dryas punctata*. Tussocks of grass (*Arctagrostis latifolia*) and small Sedges are abundant. The first Daurian Larches (*Larix dahurica*) appear in these Dwarf-Birch and lichen heaths on the valley-sides, in scattered groups, or as isolated, small, lichen-draped trees.

The Mountain Tundra

The Dwarf-Birch heaths spread over the open ridges between the copses of Larch, and cover the lower mountain slopes. Willow-bush follows up the flat-bottomed copses with the same species

as in the lowlands. Higher up, the Dwarf-Birch and the bush-Willows disappear, and the northern Heath-shrublets, *Dryas punctata*, *Cassiope tetragona*, the Crowberry and the Black Bearberry scatter their low mounds, with the flat Willow *Salix reticulata*. Holy-grasses (*Hierochloa*) take the place of *Arctagrostis*, with tufts of yellow Cinquefoils (*Potentilla*), Milkvetches (*Oxytropis*), Louse-worts (*Pedicularis*) and the silky mats of *Artemisia trifurcata*. All vegetation except crustose lichens finishes at 2300 feet (or 3300 feet in the far south). The central massif of the Putorana is mostly bare rock or snow rising to more than 5000 feet, and cut by gorges, many filled by narrow, moraine-dammed lakes

Flood-Meadows

The great rivers thaw and overflow their banks in late May, bringing down piled blocks of ice, drift-wood, sand and silt, which is deposited on the flood-plain as the waters flow back into their channels. Here meadows flourish on the slightly raised ridges left by the retreating floods. They are of luxuriant grasses, Red Fescue, Meadow-Foxtail and especially the runnering Awnless Brome, *Bromus inermis*. Among the grasses, tall Cow-Parsnips (*Heracleum*) and Wild Chervil (*Anthriscus silvestris*) spread their white umbels, the fine blue spires of *Delphinium elatum* match them in height, while the pink Bistort, the lilac *Geranium silvaticum*, and white Yarrow (*Achillea*) spread a lower layer, with the deeply fringed rose flowers of *Dianthus superbus*, and the narrow dark blue spikes of *Veronica longifolia*. Here and there stand the green-white columns of *Veratrum album lobelianum* above their broad, pleated foliage. Bush-Willows border the meadows, and Sphagnum-bogs fill pools and hollows.

The flood-meadows of the east, for example along the River Anabar, are more arctic in character. The main grasses are *Arctagrostis*, the Alpine Foxtail (*Alopecurus alpinus*), and fine-leaved Fescues. The larger *Calamagrostis neglecta* grows in wetter places, with low mounds of the Willow, *Salix glauca*, the Marsh Saxifrage, *Saxifraga hirculus*, the Forgetmenot, *Myosotis asiatica*, Sedges and Cotton-grass. On raised or sandy areas, the Woolly Willow, *Salix lanata*, is more common, with *Salix reticulata*, the Dwarf-Birch, *Valeriana capitata*, Milkvetches (*Astragalus*), the thistle-like *Saussuria*, and *Polygonum viviparum*. The Horsetail, *Equisetum arvense*, the troublesome British weed, is common everywhere.

East Siberian Dwarf Pine and Tundra

In the far east, beyond the Kolymski mountains, the range of the Larch ends. Along the coastal mountain slopes and in the seaward-facing basins of the Anadyr and Penzhina rivers, strong northerly winds sweep in from the Arctic bringing lashing snow-blizzards. During the summer the

air-stream of the southeast monsoon, cooled by ice-floes in the Sea of Okhotsk, drives cold rain-storms and fog over the land and against the mountain barriers. The temperatures are never so low as in the interior, but the weather is bleak and cold, even in summer.

The lowlands of the Anadyr and Penzhina rivers are wet, with permanently frozen subsoil at a shallow depth. They are covered by the hummocks and pools of the Tussock-Tundra, very like that in Alaska, with tracts of the big turfs of the Cotton-grass *Eriophorum vaginatum* forming mounds on which Heath-shrubs and Dwarf-Birches (*Betula exilis*) grow in lichens. Wet mossy channels run between them, with Sphagnum, and beds of Sedges (*Carex*) spread where the water trickles. Sometimes another dwarf Birch, *B. middendorffii*, forms low tangles with the Dwarf-Alder (*Alnus fruticosa*) among the lichens, and with Bog-moss in the hollows. On the mountain sides, the lowland Tundra soon merges into Mountain-Tundra, mainly of lichens with *Dryas* and small herbs, or stunted Heathshrubs, *Cassiope ericoides*, Black Bearberry, and *Rhododendron kamtschaticum*. Wet mossy hollows and watercourses are overgrown by Sedges. The first outliers of Coniferous Forest appear on the inland mountain slopes. Bush-like trees of the Birch *Betula ermanni* are to be found in the Dwarf-Birch and Alder scrub, and a little higher, on well-drained stony slopes facing south, the low, sombre-green mounds of the Dwarf-Pine *Pinus pumila*, spreading several trunks along the ground. Nowhere are there trees, except for copses of low Poplars along the river banks, and the Coniferous Forest take the form of elfinwood for hundreds of miles on the seaward slopes of the Kolymski mountains, all the lower altitudes of the Kiriakski range, and south into Kamchatka.

The flood-meadows along the rivers show as strips and lines of brighter green through the Tundra. The eastern Small-reed *Calamagrostis langsdorffii* and sedges (*Carex*) form the main part of the sward. Bush-Willows edge the meadows on the stream banks, and groves of the Balsam Poplar, *Populus suaveolens*, two or three times a man's height, grow in sheltered valley-heads. Among them may be stands of the tall and handsome rose-magenta Rosebay Willowherb, *Chamaenerium (Epilobium) angustifolium*. The little Arctic Bramble, *Rubus arcticus*, creeps between the Sedge and grass tussocks of the meadows with *Trientalis europaea* and *Viola repens*. Taller plants are the narrow-leaved clumps of *Achillea (ptarmica) sibirica*, with flat heads of small white daisies, the Cranesbill, *Geranium erianthum*, Buttercups (*Ranunculus monophyllus*) and *Aster sibiricus* raising lilac or violet, golden-centred suns, one to a ranch, on leafy stems up to two feet high.

The southernmost part of Kamchatka (where the mountains are not so high as in the centre of the peninsula), and the islands offshore, the northern Kuriles, the Komandorskie, and Karaginski Islands, are windswept, cold, foggy and wet. There are no tall trees, but only patches of elfinwood of Dwarf-Pine and a few stunted Birches on the stony hillsides. Most of the lowlands are wet and

peaty with wide marshes of Sedge (*Carex*), Rush (*Juncus*) and Small-reed grass (*Calamagrostis*), with the Cotton-grass *Eriophorum angustifolium* running in the channels. Here also the Kingcup, *Caltha palustris*, opens its polished yellow blooms with the lilac-purple flowers of *Iris setosa* among its clumps of grassy leaves, the white or pale lilac Cuckoo-flower *Cardamine pratensis*, the crimson-spiked Burnet *Sanguisorba tenuifolia*, and the Orchid *Limnorchis convallarieafolium*. In many places moss-bogs occur and build up peat, the hummock-tops of which are overgrown by the usual *Andromeda polifolia*, Cloudberry (*Rubus*), Bog-Whortleberry, Crowberry, Leatherleaf (*Chaedaphne*) and Labrador-Tea (*Ledum*), with Cranberry (*Oxycoccus*) and the Common Sundew *Drosera rotundifolia* on wetter peat. Where the drainage water runs are dwarf Willows (*Salix*), or here and there a stunted Mountain-Ash *Sorbus sambucifolia*, with the Orchid *Orchis aristata* or the white fluffy spikes of *Polygonum viviparum* and colonies of the shiny rich-green foliage and deep maroon, almost black, bells of *Fritillaria camtschatcensis*.

The Forest-Tundra of Alaska

General Description

Central Alaska is a plateau, cut by the valleys of the River Yukon and its tributaries. The soils are of glacial origin. Great mountain chains rise to the south and north of the Yukon plateau, bearing only Mountain-heath and Tundra. The plateau country itself is hilly, and is covered by open Tussock and edge Tundra; by groves of Spruces and Birches, edged with bushland; or by Lichen-heaths, with shall Muskegs filling all depressions.

The first outliers of the Boreal Forest are dense thickets of low Birches on gentle slopes in the lowlands. The Dwarf-Birch (*Betula exilis*) is a variable species, and taller forms of it grow in the thickets, mixed with the more tree-like Ground Birch (*Betula glandulosa*). These small trees have several trunks which spread outwards on the ground and then bend upwards, reaching a height of eight feet in the most sheltered places. In openings among them are the shrub-Willows, dwarf Heath bushes, and grasses of the Tundra, with a creeping Feather-moss carpet (unlike the upright mound-mosses of the Tundra). Tall lichens are conspicuous on the raised parts of the hummocky soil. At the head of quiet bays of the west coast, and on the flood-plains of the rivers, Balsam Poplars about fifteen feet tall, and bush-Alders take the place of the low species of Birch, and on south-facing slopes, the large Alaska White Birch grows.

In these Birch and Poplar woods, with their undergrowth of bushes, the first White Spruces appear. They become more frequent on fairly steep slopes above the rivers, until inland over the central plateau, they form their groves and open forests, between the treeless mountain ranges, to the head-waters of the Yukon.

Alaska

Spruce Open Forest (Forest-Tundra)

The White Spruce, *Picea glauca*, grows in these northern woods to about twenty or thirty feet tall, as very slender, dark spires. Even when standing close together in groves, it rarely shades all the ground. Among the trees is an undergrowth of shrubs, some six to ten feet high, of *Spiraea beauverdiana*, Willows, wild Currants (*Ribes*), *Potentilla fruticosa*, and the Rose, *Rosa acicularis*, a vigorous, bristly bush, with blue-green foliage, and large, bright pink flowers, followed by pear-shaped red hips. The bushland spreads out round the copses, with small Spruces standing in it. The Heath-Tundra shrublets, growing taller in the shelter, tangle together in gaps, and out onto the Tundra. Strong tussocks of the grasses *Calamagrostis canadensis*, conspicuous with purple plumes when in bloom, and *Festuca altaica* are common, with stands of the vivid mauve-red of the Fireweed, *Chamaenerium angustifolium*. Horsetails (*Equisteum*), ferns, and the leafy *Mertensia paniculata*, uncurling heads of blue trumpets, grow among the bushes. Where the soil is thin and dry, lichens grow tall and form pale grey mats. The wide, rounded crowns of the Alaska White Birch, *Betula resinifera*, are commonly scattered among the Spruces, and form shady groves of their own here and there along streams. They grow with a few Balsam Poplars, *Populus tacamahaca*, which, however, prefer the terraces of the river plains, where they make dense stands. Between the groves of trees spreads the Tundra, grey with lichens, or dark with Heath-shrubs. In badly-drained areas, ancient lake-beds and hollows, Muskegs (or moss-bogs) develop. In these places, the White Spruce gives way to the Black Spruce, *Picea mariana*, stunted and scattered on the sodden hummocks, with here and there round the edges, a few Tamaracks (*Larix laricina*).