Long-term changes in vegetation and land use in mountainous areas with heavy snowfalls in northern Japan: An 80-year comparison of vegetation maps

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**Table S1**. Vegetation legend for 1930 (left), 2010 (middle), and the present study (right).

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| 1930 | 2010 | Unified vegetation type (abbreviation) |
| *1. Fagus crenata* forest (DaI),  2. *Betula ermanii* degeneration community (Bd) | 1. *Saso kurilensis-Fagion crenatae* | 1. Beech forest (BeF) |
| 3. *Fagus crenata-Quercus crispula-Acer pictum* forest (DaIII),  4. *Fagus crenata* degeneration community (DaIV),  5. *Quercus crispula* forest (Db) | 2. *Fagus crenata-Quercus crispula* community,  3. *Fagus crenata* secondary forest,  4. *Lindero membranaceae-Quercetum mongolicae* *grosseserratae*,  5. *Carpinus laxiflora* community,  6. *Quercus dentata* community | 2. Deciduous oak forest (DeO) |
| 6. *Cryptomeria japonica* forest,  7. Subalpine fir forest (*Abies mariesii* with *Tsuga diversifolia*, *Betula ermanii*, *Sasa kurilensis, Quercus crispula* var*. horikawae*) (BaI, BaII, Bb, Bc, Cc) | 7. *Tsuga diversifolia* community, 8. *Betula ermanii* community, 9. *Abietetum mariesii*, 10. *Quercus crispula* var. *horikawae* community | 3. Subalpine fir forest (SuF) |
| ― | 11. Plantation forest (*Cryptomeria japonica*, *Chamaecyparis obtusa*, *Chamaecyparis pisifera*, other Deciduous broadleaved trees, *Larix kaempferi*) | 4. Plantation forest (PlF) |
| 8. *Sasa kurilensis* degeneration community (Be) | 12. Dwarf bamboos,  13. *Menziesio-Quercion* | 5. Sasa grassland (SaG) |
| 9. *Fagus crenata-Aesculus turbinata* forest (DaII)  10. *Aesculus turbinata-Pterocarya rhoifolia-Cercidiphyllum japonicum* forest (Dc), | 14. *Polysticho-Pterocaryetum*,  15. *Zelkova serrata* secondary forest,  16. *Ulmus davidiana* forest | 6. Riparian forest (RiF) |
| 11. Deciduous shrub (Ab) | 17. *Sasa*-*Betula ermanii* community,  18. *Trollio-Ranunculion acris japonici*,  19. *Betuletum ermanii* | 7. Birch forest (BiF) |
| ― | 20. Golf course,  21. Lawn,  22. Pasture land | 8. Pasture land (PaL) |
| 12. *Pinus parviflora−Pinus densiflora* forest (Cb) | 23. *Pinus densiflora* community,  24. *Alnus pendula-Weigela hortensis* community,  25. *Alnus hirsuta* community | 9. Pioneer shrub (PiS) |
| 13. Petrideserta (H), 14. Upland grassland (Eb) | 26. *Arundinello-Miscanthion sinensis*,  27. *Zoysion japonicae*,  28. *Moliniopsietalia japonicae*,  29. Bare land,  30. Solfatara fields | 10. Natural grassland (NaG) |
| 15. Alpine bog (F) | 31. *Oxycocco-Sphagnetea* | 11. Alpine bog (AlB) |
| ― | 32. Urban area, 33. Developed land, 34. Roadside/Open space | 12. Urban area (UrA) |
| 16. *Pinus pumila* shrub (Aa),  17. Alpine grassland (Ea) | 35. *Vaccinio-Pinetum pumilae*, 36. *Pinus pumila* community | 13. Alpine meadow (AlM) |
| ― | 37. Snowpatch grassland | 14. Snowpatch grassland (SnG) |
| ― | 38. Deforestation community | 15. Deforestation area (DeA) |
| 18. *Thujopsis dolabrata* forest (CaI)  19. *Thuja standishii* (CaII), | 39. *Thuja standishii-Pinus parviflora* var. *pentaphylla* community | 16. Temperate conifer forest (TeC) |
| ― | 40. *Salix* community | 17. Willow forest (WiF) |
| ― | 41. Lowland weed community, 42. Upland weed community | 18. Agricultural land (AgL) |
| 20. Wetland (G) | 43. *Phragmitetea,* 44. *Potametea* | 19. Reed bed (ReB) |
| 21. Open water | 45. Open water | 20. Open water (OpW) |
| 22. Non-classified | ― | 21. Non-classified (NoC) |

**Table S2.** Main species composition for each vegetation in 1930. The species composition was listed referencing the Sibata et al. (in press) and the data of the Vegetation Survey Section of the Aomori Forestry Bureau in the 1930s.

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| Vegetation legend for 1930 | Species |
| *1. Fagus crenata* forest, | *Fagus crenata*, *Acer japonicum*, *Viburnum furcatum*,  *Hydrangea petiolaris*, *Lindera umbellata* var. *membranacea*, *Aucuba japonica* var. *borealis*, *Chengiopanax sciadophylloides*, *Ilex leucoclada*, *Sasa kurilensis*, *Cephalotaxus harringtonia* var. *nana*, *Toxicodendron radicans* subsp. *orientale*, *Dryopteris crassirhizoma*, *Sorbus commixta* |
| *2. Betula ermanii* degeneration community | *Fagus crenata*, *Acer japonicum*, *Viburnum furcatum*, *Hydrangea petiolaris*, *Sorbus commixta*, *Betula ermanii,* *Fraxinus lanuginosa*, *Sasa kurilensis*, *Maianthemum dilatatum* |
| *3. Fagus crenata-Quercus crispula-Acer pictum* forest, | *Fagus crenata*, *Acer japonicum*, *Viburnum furcatum*,  *Hydrangea petiolaris*, *Lindera umbellata* var. *membranacea*, *Quercus crispula* var. *crispula*, *Euonymus alatus* f. *striatus*, *Toxicodendron radicans* subsp. *orientale*, *Acer pictum* subsp. *mayrii*, *Maianthemum dilatatum*, *Aria alnifolia* |
| *4. Fagus crenata* degeneration community, | *Fagus crenata*, *Acer japonicum*, *Viburnum furcatum*,  *Hydrangea petiolaris*, *Thelypteris pozoi* subsp. *mollissima*, *Sorbus commixta*, *Salix reinii*, *Maianthemum dilatatum* |
| *5. Quercus crispula* forest | *Fagus crenata*, *Quercus crispula* var. *crispula*, *Acer japonicum*, *Hydrangea petiolaris*, *Euonymus alatus* f. *striatus*, *Toxicodendron radicans* subsp. *orientale*, *Kalopanax septemlobus*, *Acer pictum* subsp. *mayrii*, *Sorbus commixta*, *Cephalotaxus harringtonia* var. *nana*, *Aria alnifolia* |
| *6. Cryptomeria japonica* forest, | *Abies mariesii*, *Cryptomeria japonica*, *Arachniodes mutica*, *Plagiogyria matsumurana*, *Coptis trifolia*, *Skimmia japonica* var. *intermedia* f. *repens*, *Ilex sugerokii* var. *brevipedunculata*, *Eubotryoides grayana* var. *grayana*, *Hydrangea petiolaris*, *Tripterospermum trinervium*, *Mitchella undulata*, *Rhododendron brachycarpum* var. *brachycarpum*, *Huperzia serrata* var. *serrata*, *Sasa kurilensis* |
| 7. Subalpine fir forest (*Abies mariesii* with *Tsuga diversifolia*, *Betula ermanii*, *Sasa kurilensis, Quercus crispula* var*. horikawae*) | *Abies mariesii*, *Viburnum furcatum*, *Plagiogyria matsumurana*, *Coptis trifolia*, *Skimmia japonica* var. *intermedia* f. *repens*, *Ilex sugerokii* var. *brevipedunculata*, *Eubotryoides grayana* var. *grayana*, *Sorbus commixta*, *Oplopanax japonicus* var. *brevilobus*, *Sasa kurilensis*, *Acer tschonoskii*, *Vaccinium ovalifolium*, *Ilex crenata* var. *radicans*, *Maianthemum dilatatum*, *Rhododendron pentandrum* |
| 8. *Sasa kurilensis* degeneration community | *Sasa kurilensis*, *Acer tschonoskii*, *Elliottia bracteata*, *Solidago virgaurea* subsp. *gigantea*, *Peucedanum multivittatum*, *Vaccinium ovalifolium*, *Ilex crenata* var. *radicans*, *Viburnum furcatum*, *Abies mariesii*, *Coptis trifolia*, *Skimmia japonica* var. *intermedia* f. *repens*, *Ilex sugerokii* var. *brevipedunculata*, *Eubotryoides grayana* var. *grayana*, *Sorbus commixta*, *Ilex leucoclada*, *Maianthemum dilatatum*, *Helonias orientalis*, *Schizocodon soldanelloides* var. *soldanelloides* |
| 9. *Fagus crenata-Aesculus turbinata* forest | *Pterocarya rhoifolia*, *Aesculus turbinata*, *Dryopteris crassirhizoma*, *Arachniodes standishii*, *Hydrangea serrata* var. *yesoensis*, *Acer pictum* subsp. *mayrii*, *Fagus crenata*, *Hydrangea petiolaris*, *Lindera umbellata* var. *membranacea*, *Dryopteris monticola*, *Cephalotaxus harringtonia* var. *nana* |
| 10. *Aesculus turbinata-Pterocarya rhoifolia-Cercidiphyllum japonicum* forest, | *Pterocarya rhoifolia*, *Aesculus turbinata*, *Dryopteris crassirhizoma*, *Arachniodes standishii*, *Hydrangea serrata* var. *yesoensis*, *Acer pictum* subsp. *mayrii*, *Hydrangea petiolaris*, *Cercidiphyllum japonicum*, *Filipendula camtschatica*, *Polystichum tripteron*, *Petasites japonicus* subsp. *giganteus*, *Matteuccia struthiopteris* |
| 11. Deciduous shrub | *Sasa kurilensis*, *Acer tschonoskii*, *Sorbus commixta*, *Betula ermanii* |
| 12. *Pinus parviflora−Pinus densiflora* forest | *Pinus parviflora* var. *pentaphylla*, *Quercus crispula* var. *crispula*, *Aria alnifolia* |
| 13. Petrideserta, | *Solidago virgaurea* subsp. *gigantea*, *Artemisia keiskeana*, *Saxifraga fortunei* var. *alpina* |
| 14. Upland grassland | *Blechnum niponicum*, *Gnaphalium japonicum*, *Rosa multiflora*, *Gonocarpus micranthus*, *Cerastium fontanum* subsp. *vulgare* var. *angustifolium*, *Rumex acetosella* subsp. *pyrenaicus*, *Zoysia japonica*, *Senecio cannabifolius*, *Carex nubigena* subsp. *albata*, *Pteridium aquilinum* subsp. *japonicum*, *Salix reinii* |
| 15. Alpine bog | *Drosera rotundifolia*, *Narthecium asiaticum*, *Hosta sieboldii* var. *rectifolia*, *Nephrophyllidium crista-galli* subsp. *japonicum*, *Sieversia pentapetala* |
| 16. *Pinus pumila* shrub, | *Pinus pumila*, *Spiraea betulifolia* var. *betulifolia*, *Vaccinium vitis-idaea*, *Maianthemum dilatatum*, *Calamagrostis sachalinensis*, *Solidago virgaurea* subsp. *gigantea*, *Empetrum nigrum* var. *japonicum*, *Ilex rugosa*, *Sorbus commixta*, *Salix reinii*, *Alnus viridis* subsp. *maximowiczii* |
| 17. Alpine grassland | *Alnus viridis* subsp. *maximowiczii*, *Phyllodoce aleutica*, *Pedicularis chamissonis* var. *hokkaidoensis*, *Arnica unalaschcensis* var. *tschonoskyi*, *Cimicifuga japonica*, *Tilingia ajanensis*, *Nephrophyllidium crista-galli* subsp. *japonicum*, *Schizocodon soldanelloides* var. *soldanelloides*, *Sieversia pentapetala* |
| 18. *Thujopsis dolabrata* forest | *Thuja standishii*, *Acer micranthum*, *Fraxinus sieboldiana*, *Acer rufinerve*, *Aria alnifolia*, *Hydrangea paniculata*, *Rhododendron pentandrum*, *Pinus parviflora* var. *pentaphylla*, *Carpinus laxiflora*, *Cerasus maximowiczii*, *Rhododendron albrechtii*, *Rhododendron tschonoskii*, *Toxicodendron trichocarpum*, *Elliottia paniculata*, *Vaccinium smallii* var. *smallii* |
| 19. *Thuja standishii* | *Thuja standishii* |
| 20. Wetland | *Phragmites australis*, *Potamogeton fryeri*, *Isoetes japonica* (includes various communities) |
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|  |  | 2010 | | | | | | | | | | | | | | | | | | | |
|  |  | BeF | DeO | SuF | PlF | SaG | RiF | BiF | PaL | PiS | NaG | AlB | UrA | AlM | SnG | DeA | TeC | WiF | AgL | ReB | OpW |
| 1930 | BeF | 72.55 (64.77) | 17.65 (15.76) | 0.66 (0.59) | 9.89 (8.83) | 2.55 (2.28) | 2.94 (2.62) | 2.29 (2.05) | 1.95 (1.74) | 0.67 (0.6) | 0.14 (0.12) | 0.08 (0.07) | 0.16 (0.14) | - | 0.02 (0.02) | 0.08 (0.07) | 0.09 (0.08) | 0.02 (0.02) | 0.14 (0.13) | - | 0.12 (0.11) |
| DeO | 49.8 (61.78) | - | - | 13.88 (17.22) | 1.26 (1.56) | 6.29 (7.81) | 1.18 (1.47) | 3.28 (4.07) | 0.65 (0.81) | 1.66 (2.06) | 0.11 (0.14) | 0.79 (0.98) | - | - | 0.36 (0.45) | 0.21 (0.27) | 0.24 (0.3) | 0.01 (0.01) | 0.03 (0.03) | 0.84 (1.04) |
| SuF | 18.45 (25.44) | 0.91 (1.26) | 30.94 (42.65) | 0.02 (0.02) | 14.81 (20.42) | 0.01 (0.01) | 2.94 (4.06) | - | 1.28 (1.76) | 0.21 (0.28) | 1.64 (2.26) | 0.08 (0.1) | 0.5 (0.69) | 0.62 (0.86) | 0.06 (0.08) | - | - | - | - | 0.08 (0.11) |
| SaG | 0.11 (17.11) | - | 0.3 (48.61) | - | - | - | 0.12 (19.53) | - | - | - | - | - | 0.01 (1.39) | 0.08 (13.35) | - | - | - | - | - | - |
| RiF | 22.17 (46.57) | 8.32 (17.47) | 0.01 (0.01) | 7.6 (15.96) | 0.08 (0.16) | 5.52 (11.6) | 0.28 (0.59) | 2.06 (4.33) | 0.33 (0.7) | 0.11 (0.24) | 0.07 (0.14) | 0.3 (0.63) | - | - | 0.07 (0.16) | 0.01 (0.03) | 0.12 (0.25) | - | - | 0.55 (1.16) |
| BiF | 0.7 (17.8) | - | 0.39 (9.79) | - | 2.05 (52.12) | - | 0.52 (13.2) | - | 0.16 (4.05) | 0.02 (0.61) | 0 (0.04) | - | 0.09 (2.26) | 0.01 (0.14) | - | - | - | - | - | - |
| PiS | 0.03 (5.42) | 0.35 (55.49) | - | - | - | 0 (0.72) | - | - | 0.03 (3.92) | 0 (0.63) | - | 0 (0.08) | - | - | - | 0.1 (15.35) | - | - | - | 0.12 (18.4) |
| NaG | 0.84 (21.71) | 0.64 (16.38) | - | 0.42 (10.7) | 0.06 (1.44) | 0.09 (2.24) | 0.19 (5.02) | 0.32 (8.14) | 0.14 (3.68) | 0.89 (22.86) | 0.02 (0.62) | 0.06 (1.65) | - | - | 0 (0.06) | 0.06 (1.51) | 0.05 (1.25) | - | - | 0.11 (2.74) |
| AlB | 0.25 (7.66) | 0.19 (5.93) | 0.99 (30.78) | - | 0.61 (18.83) | 0.01 (0.2) | 0.26 (8.17) | 0 (0.08) | 0.05 (1.4) | 0.06 (1.87) | 0.62 (19.11) | 0.07 (2.24) | 0.01 (0.3) | 0.05 (1.49) | 0 (0.13) | - | 0.02 (0.52) | - | 0.03 (0.96) | 0.01 (0.33) |
| AlM | 0.08 (5.27) | - | 0.19 (11.66) | - | 0.39 (24.64) | - | 0.07 (4.58) | - | 0.01 (0.7) | 0.04 (2.38) | - | 0.04 (2.36) | 0.62 (38.86) | 0.15 (9.45) | - | - | - | - | - | 0 (0.11) |
| TeC | - | 0.02 (47.01) | 0 (6.87) | - | - | - | - | - | - | - | 0 (3.99) | - | - | - | - | 0.02 (34.81) | - | - | - | 0 (7.32) |
| ReB | 0.03 (9.21) | 0.05 (14.99) | - | - | 0 (0.11) | 0.01 (1.97) | - | 0.01 (3.84) | 0 (0.58) | - | - | 0.02 (4.28) | - | - | - | 0.01 (1.81) | 0 (0.55) | - | 0 (0.66) | 0.23 (62.02) |
| OpW | 0.06 (0.11) | 0.24 (0.4) | - | 0 (0.01) | - | 0.04 (0.07) | - | - | 0.01 (0.01) | 0.01 (0.02) | - | 0.02 (0.03) | - | - | - | 0.03 (0.05) | - | - | - | 59.3 (99.32) |
| NoC | 1.04 (19.36) | 1.24 (23.07) | 0.06 (1.04) | 0.26 (4.81) | 0.04 (0.79) | 0.88 (16.35) | 0.05 (1.01) | 0.15 (2.74) | 0.07 (1.38) | 0.1 (1.87) | 0 (0.07) | 0.98 (18.26) | - | - | 0.01 (0.19) | - | 0.01 (0.26) | 0.15 (2.81) | 0 (0.01) | 0.32 (5.98) |

**Table S3.** Matrix table of changes in area (km2) covered by vegetation in the Hakkoda Mountains between 1930 and 2010 based on 21 unified vegetation types. Numbers in parentheses are percentages. See Table S1 for the full name of each vegetation type.