（3）飯豊・朝日連峰、奥利根・奥只見（多雪環境とブナ林）

1）事前説明資料

1．自然の概要

1-1　飯豊・朝日連峰

1-1-1　地形・地質

出羽三山を代表する月山は、第三紀の基盤山地の上に乗る第四期後期に形成された火山で、飯豊・朝日山地は花崗岩と中古生層から成る褶曲山地である。各地とも氷河地形や周氷河地形及び雪食地形（特に朝日山地で発達）が見られ、稜線の東西で地形が大きく異なる非対称山稜を形成していることが、大きな特徴として挙げられる。

1-1-2　植物相

出羽三山、飯豊・朝日とも、ブナ林を中心とする山岳地帯で、冬の季節風の影響を受ける世界的にも有数の豪雪地帯である。このため、古い氷食地形を土台にした雪食地形が発達しているほか、亜高山帯の樹林帯を欠く「偽高山帯」が広く形成されている等、「多雪」による独特な特徴を有する。

1,500m 以下ではブナ林（落葉広葉樹林）が広がり、原生的な森林が残された地域として評価される。また鳥海山・月山・朝日連峰は、多雪地帯であるため 1,500m 以上の標高ではすぐにミヤマナラ・ナナカマドなどの落葉低木群落やチシマザサ群落、雪田群落となり、通常森林帯と高山帯の中間の標高に存在する亜高山性の針葉樹林を欠く「偽高山帯」を形成している点が特徴である。また、冬期の季節風の風下に当たる月山などの山脈東面には、国内有数の規模を誇る雪渓（雪田）が形成され、多彩な高山植物からなる雪田群落が発達している。

飯豊山の植生も朝日連峰と同様に雪田群落など多雪地帯の特徴をよく示す。400～1,500mまでブナを中心とした原生林が広がり、雪崩が頻繁に発生する場所ではブナ林が分断されて、マルバマンサクなど低木林が成立し、植生分布や垂直分布帯の複雑さが特徴的である。ブナ林の林床には、多雪地域に適合したユキツバキ等がしばしば優占する。

1-1-3　動物相

朝日山地だけで哺乳類 42 種、鳥類 102 種、両生類 15 種という記録もあり、全般に動物相は豊かである。地域全体でツキノワグマやカモシカなどの大型哺乳類の個体数も多く、分布も広範囲に及んでいる。鳥類では天然記念物のイヌワシの他、クマタカやオオタカ、ハヤブサなどの猛禽類が見られる。昆虫類ではアサヒナガチビゴミムシ、イイデナガチビゴミムシ、ガッサンナガチビゴミムシなどが生息し、月山、朝日山連峰、飯豊山系で独特な種分化を形成している。

1-2　奥利根・奥只見

1-2-1　地形・地質

太平洋側と日本海側の分水嶺の南部にあたり、我が国有数の豪雪地帯である。このため雪の影響を受けた独特の自然景観、雪崩（アバランチ・シュート）、節状地形ヒド（融雪水によって作ら

れたガリー)、周氷河地形が特徴的である。また、越後三山地域は、比較的新しい地質時代に著しい隆起運動により形成され、急峻な浸食地形を呈している。奥利根地域は越後山脈の南端にあたり、標高 2,000m 内外の山々が連なる険しい地形を有する。夏季にも各所に多量の残雪が認められ、雪食凹地や階段状地形がみられる。水長沢山の西麓に分布するモノチス含有化石層は層厚 100～150m、総延長約 1,000m と国内最大規模であり、殻質が付着した化石も産出している。

1-2-2　植生

①奥利根

雪崩、雪圧、残雪、融雪水など多雪地域特有の影響を受けた植生が分布する。V 字状の渓谷が多いため多雪地の渓谷林も発達している。当地域の植生として、海抜 850m（奥利根湖）から約 1,600m付近までがブナクラス域であり、マルバマンサクーブナ群集が雪崩の少ない山裾の緩傾斜地やテラス状地を覆っている。雪崩地や崩壊性の斜面にはミヤマナラ群集などが成立し、標高 1,700m以上の雪田群落などが特徴であり、多くの北方系の固有植物が残存している。一部の斜面では、樹幹が斜面を下方に匍匐しながら先端部が斜上するブナ林がみられる。稜線部は多雪と冬季卓越風のため、亜高山常緑針葉樹林が一部を除いて欠落している（偽高山帯)。

②奥只見

当地域の植生として、ブナの原生林とブナ林の伐採後に発達した二次林、ダケカンバ林、および日本海側の多雪地帯に形成されるミヤマナラの亜高山帯低木性広葉樹林が特徴である。また、越後三山には偽高山帯が見られる。

1-2-3　動物相

多様な地形・地質、気候、植生により、多くの哺乳類、鳥類、昆虫類が生息している。哺乳類では、特別天然記念物のニホンカモシカをはじめ、ツキノワグマ、ニホンジカ、ニホンザルなどの大型哺乳類、キツネや天然記念物のヤマネなどの中・小型哺乳類を合わせ 7 目 15 科 49 種が確認されている。希少種としては、IUCN のレッドリスト絶滅危惧種に２種（モリアブラコウモリ、ヤマネ）指定されている。

天然記念物に指定されているイヌワシなど多くの鳥類が、森林や湖沼、湿原など様々な環境に生息している。各地域で確認されている鳥類種数は、奥利根地域では 90 種、奥只見地域では 78 種にのぼる。

２．世界遺産としての価値の可能性　－多雪環境とブナ林－

2-1　多雪環境

北半球の北緯 40 度付近で積雪深が 1m を超えるのは、高山を除けばアメリカ北東部など極めて限られた地域である。また、アジア東岸の中緯度地域において 1m を超える積雪のみられる地帯は日本以外には、中国東北部と北朝鮮にまたがる長白山地のみであり、日本が東アジアの地域の中で例外的に多雪である。

山地では水蒸気を含んだ季節風が、山地にぶつかって強制的に上昇させられたときに多量の降

雪がもたらされる。したがって、多量の降雪が起こる要因には、豊富な水蒸気の供給源と強い季節風、季節風に立ちはだかる山地地形である。日本列島の風上側の日本海には暖流である対馬海流が流れており、多量の水蒸気を供給する。また、冬の日本は大陸にできるシベリア高気圧とアリューシャン低気圧の間にあって、気圧の勾配が大きく、強風の季節風が発生しやすい条件下にある。こうしてできた湿った季節風が脊梁山脈を通過する過程で多量の降雪をもたらすことになる。

2-1-1　偽高山帯

当地域では、森林限界より上に高木林はほとんど見られず、亜高山帯に相当する標高を持ちながら亜高山帯性の針葉樹林（オオシラビソ林）がごく小規模に分布するか、あるいは全く存在せず、代わりにミネカエデやナナカマドなどの落葉低木群落やチシマザサのササ原によって覆われている。こうした針葉樹林を欠く亜高山帯の領域は偽高山帯と呼ばれている。偽高山帯の成因については多雪地域の雪圧、強風、地形的要因や後氷期の環境変化による植生への影響などが考えられている。

偽高山帯の景観は、主に東北地方から中部地方にかけての山々で見られ、特に東北地域では月山、鳥海山をはじめとして白神岳、岩木山、朝日岳、飯豊山など、また上越山地の越後三山、谷川連峰や北アルプス北部などの日本海側の山地に多く見られる。奥羽山脈の秋田駒ヶ岳、栗駒山、安達太良山など日本海側に面していない山域でも偽高山帯が見られる。

2-1-2　積雪グライドの植生への影響

山地斜面に降り積もった積雪層が自重によって滑り落ちようとする現象を積雪グライドと呼んでいる。積雪グライドはゆっくり進むが、巨大な圧力（雪圧）を伴っており、地表や地上の植物に雪圧をかけ続けることにより、樹形や植生に大きな影響を与える。

積雪グライド駆動力が飯豊山や朝日岳などで極めて大きいことは、積雪深の大きさだけでなく、谷ひだの深い急峻な山地地形を持っているからである。亜高山帯の樹林帯を欠く偽高山帯の形成要因の一つとして積雪グライドや雪崩が考えられている。

2-1-3　雪田群落及びその周辺の植生

飯豊山から御西岳の主陵の直下に越年する雪田（雪窪）がある。雪田の山稜は風衝地で乾燥しやすく、夏期には乾性のお花畑となり、コメバカズラやミネズオウ、ハイマツなどの小低木が中心とした嫌雪性の植物群落となる。雪田周辺ではアオノツガザクラやモミジカラマツ、フキユキノシタ、イワイチョウなど、多雪地帯に見られる好雪性の植物群落が取り巻き、雪田の岩屑原には湧水によって、クロクモソウ、フキユキノシタ、ヒメアカバナが生育し、雪田の最下部には、モミジカラマツの群落で、ヌマガヤやオオバショリマなどの草原となる。雪田という独特な地形では、植物の分布は、それを取り囲むように同心円状に分布し、多様な植物相が見られる。

2-2　ブナ林

2-2-1　日本のブナ林の植物社会学的体系

日本のブナの分布域は年平均気温 6～13℃、年降水量 1,300mm 以上の地域で、水平的には冷温帯、垂直的には山地帯と呼ばれる。このような気候条件から潜在的な分布の中心は中部地方以東にあり、広い面積を占めている。日本のブナ林は、種組成の違いを植物社会学的方法によって比較することで、5 つの群集に分けられる（図）。

林冠の構成種数を比較したところ、日本海側のブナ林のグループは平均 2.9 種であったのに対し、太平洋側では 10.3 種との報告がある。また、日本海側のチシマザサーブナ群集の種構成は、地域による差が著しく少ないという特徴がある。したがって、日本海側ではブナが純林に近い林をつくっており、これは冬の大量の積雪により、春先から初夏にかけて土壌が湿潤に保たれ、ブナの生育に好適な条件を提供するためと考えられる。

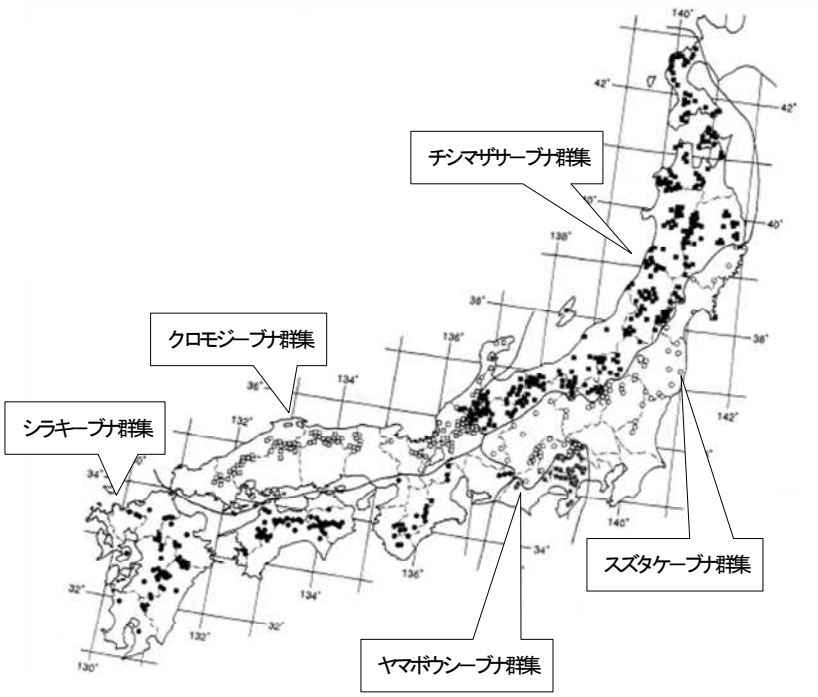


図　日本のブナ林群集の分布（福嶋ほか，1995 より一部改編）

2-2-2　国内外のブナ林

ブナ属は、世界ではヨーロッパ、東アジア、北アメリカの 3 地域に隔離分布されており、東アジアのブナ林は、福嶋ほか（2013）によるとさらに 3 つのクラスに区分される。日本と韓国がブナクラス、中国と台湾がムシャダモーブナクラスに属し、中国の雲南省南部とベトナムは常緑樹林クラス（クラス名未同定）である。

日本は韓国のウルルン島（鬱陵島）と類似する特徴を持ち、韓国のウルルン島のタケシマブナ林とともにブナクラスに分類されている。このクラスの特徴は落葉樹が多く、常緑広葉樹が少な

いことである。

ウルルン島のタケシマブナ林は、多雪環境下に生育し、ブナの純林を形成する点、林床に一部チシマザサが優占する点で、日本の日本海側のブナ林と類似するが、林床は主にシダ類が生育する。タケシマブナ林は、ウルルン島の島全域には分布しておらず、仮に島全域と見なしても、白神山地の遺産地域（17,000ha）や奥会津森林生態系保護地域（83,890ha）より狭く、純林をなすブナ林の面積は日本のほうが遙かに広いことになる。

ヨーロッパブナ林は、樹冠層がほとんどブナ林に占められる点で、ウルルン島同様、日本の日本海側ブナ林と類似する。しかし、ヨーロッパブナ林の種組成は、日本のブナ林の 1/5 から 1/6 といわれ、日本のブナ林よりも多様性は高くないこと、多雪環境に影響を受けた生態を有していないことから、日本のブナ林と相違している。

アメリカブナに関しては、日本のブナのように単独で優占林を作ることはほとんどなく、林の構成種のひとつとして生育し、アメリカ南部では常緑林と混交することが特徴である。

国内のブナ林について見てみると、既に世界遺産に登録されている白神山地と候補地として考えられている飯豊・朝日、奥利根・奥只見も含まれる日本海側のブナ林は、北海道南部（奥尻島、黒松内）から北陸にまで及び、日本海側ブナ林については、多雪環境下にあること、組成的変化は少なく、均一であることが特徴として挙げられる。

３．比較事例

3-1　カルパチア山地のブナ原生林とドイツの古代ブナ林（ドイツ連邦・スロバキア共和国・ウクライナ、2007・2011 年、(ix)）

カルパチア山地のブナ原生林とドイツの古代ブナ林は、15 地域で構成されたシリアルとしての登録地である。それらは人為の影響を受けず、複雑な温帯林の顕著な例を表し、様々な環境条件を経たヨーロッパブナの純林における最も完全かつ包括的な生態系の形態と過程を示す。また、ブナの遺伝子とそれらの森林に依存する多くの種の保存場所として重要な地域である。

カルパチア山地のブナ原生林とドイツの古代ブナ林は、北半球におけるブナ属の広範な分布とその生態学的重要性を解明する上で、ブナ属の歴史と進化を理解することが重要であり、そのために不可欠な場所である。これらの人為の影響を受けていない複雑な温帯林は、様々な環境条件を経てきたヨーロッパブナの純林の中で、最も完全かつ包括的な生態学的形態と過程を示し、海岸から山地の森林帯まですべての標高帯を代表している。ブナは温帯広葉樹林の中で最も重要な要素の一つであり、最終氷河期後の再侵入化と陸域生態系や群落の成長における現在進行中の顕著な見本である。当地は、自然のブナ林の長期保全の過程において不可欠な側面を持ち、1 つの樹種が様々な環境要因の中で、どのように優占種となったかを示している。

3-2　ウルルン島（鬱陵島）（韓国）

ウルルン島は、朝鮮半島中部の沖合東方 150km の日本海に浮かぶ火山列島で、鐘状火山であり、粘り気のある溶岩が噴き出して固まって出来た高く険しい火山を持つ。島の周囲は絶壁で囲まれている。海抜 984m、面積約 73km² ほどの島である。日本海上にあるため、本州の日本海側同様、冬期に多量の積雪がある。ウルルン島には、タケシマブナが島の中腹から山頂まで分布し、一部、

タケシマイタヤやタケシマシナノキが混入するが、ほぼ純林を形成する。また、尾根筋はツガが入ることがある。林床にはマイズルソウやギョウジャニンニクなどの草本が優占するが、一部、チシマザサが優占する林も見られる。チシマザサは日本海側のブナ林を特徴付ける種でもあり、多雪条件に適応した種である。

3-3　北アメリカ

北アメリカ大陸には、アメリカブナとメキシコブナの 2 種が存在する。このうち、アメリカブナは北緯 30 度付近から 48 度付近までの広い範囲で分布する。分布域が広いため、種としてもかなり変異の幅がある。北アメリカの夏緑樹林はブナ属よりも、むしろコナラ属を優占種とすることが多い。アメリカブナは、日本のブナのように単独で優占林を作ることはほとんどなく、これらの林の構成種のひとつとして生育する。アメリカブナの分布域は南北に広いため、混交する種は地域によって異なる。特に南部では、夏緑樹ばかりでなく、常緑樹と混交するのが特徴である。

分布域の北部から南部にかけて、アメリカブナが混交する林は主に 3 つのタイプがある。

- サトウカエデ-アメリカブナ林 : アメリカブナの林のうち、もっとも北方あるいは高所に見られるタイプ。樹冠層は、主にアメリカブナとサトウカエデの 2 種によって構成され、サトウカエデの他、コナラ属、シナノキ属、ニレ属、トチノキ属などの夏緑樹が混交する。アメリカブナの中では、日本のブナ林にもっとも近い林である。林床にはマイズルソウ属やオシダ属など北方系の種が見られる。
- 中生植物混交林 : 前者よりは南部、アパラチアからミシシッピにかけての低地、低丘陵地に見られ、樹冠層はアメリカブナの他、ユリノキ、サトウカエデその他のカエデ属、シナノキ属、クリ属、トチノキ属、コナラ属、ツガ属などの非常に多くの種により構成される。アメリカブナが占める割合は、斜面の下部や沢沿いの部分で高くなる傾向にある。
- タイサンボクーアメリカブナ林 : ジョージア、アラバマ、ルイジアナ、ミシシッピ、フロリダなどの南部の各州に見られる林で、上記タイプと異なり、多くの常緑樹を混交する点で特徴がある。林冠層ではアメリカブナとタイサンボクが優占し、この他にユリノキ、コナラ属、カエデ属、モチノキ属、フウ属、ペカン属などの種が混交する。

４．課題

日本の日本海側ブナ林（チシマザサーブナ群集）は、多雪環境の影響を受け、比較的広い範囲に純林に近い林を作ることが特徴として挙げられ、ヨーロッパ、アメリカ、中国等の海外のブナ林とはその組成や多様性に相違が見られた。

国内のブナ林では、日本海側のブナ林は、北海道南部（奥尻島、黒松内）から北陸にまで及び、多雪環境下にあること、組成的変化は少なく、均一であることが特徴として挙げられ、飯豊・朝日連峰、奥只見・奥利根・奥日光もその範囲に含まれる。これらの地域が日本海側ブナ林であることを考慮し、ブナ林の純林に着目してみると、既に白神山地が登録されていることから、それらが単独で遺産として認められることは困難である。

Iide-Asahi Mountain Ranges and the Okutone-Okutadami Mountains[1]

1. Description of the Natural Environment

1.1. Iide-Asahi Mountain Ranges

1.1.1. Topography and Geography

Mt. Gassan, highest of the Three Mountains of Dewa, is a late Quaternary volcano seated atop Tertiary mountains, while the Iide-Asahi Mountains are fold mountains made up of granite and the Mesozoic-Paleozonic layer. Glacial, periglacial and nivation topography (particularly in the Asahi Mountains) can be observed in these places, while a major feature of the region is the formation of asymmetric ridges, where the topography is significantly different on the east and west sides of the ridge.

1.1.2. Flora

Both the Three Mountains of Dewa and the Iide-Asahi Mountains are mountainous areas mainly covered in Japanese beech *Fagus crenata* forests. Impacted by winter winds, these areas have some of the heaviest snowfalls in the world. As a result, the area has many features that have resulted from heavy snowfalls – not only with a nivation topography developing over the top of ancient glacial topography, but also wide expanses of "pseudo alpine zone", where the subalpine forest has not developed.

Below 1,500m there are expanses of *F. crenata* forests (deciduous broad-leaved forests); this region is appraised as having virgin forest remaining. Since Mt. Chokai, Mt. Gassan and the Asahi Mountain Range are a heavy snowfall area, anywhere above 1,500m is covered in deciduous shrub communities such as *Quercus crispula* var. *horikawae* and Japanese rowan *Sorbus commixta*, *Sasa kurilensis* communities, and snow patch

[1] In the "Overview of the five candidate sites for the nomination to the inscription on World Heritage List", this area was mentioned as "Okutone, Okutadami and Okunikko". Because our main focus is the forests in Okutone ane Okutadami, this sheets called the area as "Okutone-Okutadami Mountains".

communities. This zone is characterized by the formation of a “pseudo alpine zone” between the normal forest zone and the alpine zone that is devoid of any subalpine coniferous forests. The eastern side of Mt. Gassan and other mountains in the range is sheltered from the winter winds and contains the highest number of snow valleys or snow patches in the country. Snow patch communities have developed in these areas, comprising a diversity of alpine flora.

The vegetation on Mt. Iide is characterized by many of the same heavy snowfall area features as the Asahi Mountain Range, such as snow patche communities. There are expanses of primeval *F. crenata* forests up to 400-1500m; heavy avalanche areas divide the beech forest, with *Hamamelis japonica* var. *obtusata* and other scrub plants growing in these places instead. This area is characterized by the complexity of the vegetation distribution and the vertical distribution. The beech forest floor is often dominated by *Camellia rusticana*, which has adapted to heavy snowfall areas.

1.1.3. Fauna

In the Asahi Mountains alone there are 42 species of mammals, 102 species of birds and 15 species of amphibians on record. There is a general abundance of fauna. The overall region has a high large mammal population distributed across a vast area, including the Asiatic black bear *Ursus thibetanus* and the Japanese serow *Capricornis crispus*. Birds include the Japanese natural monument golden eagle *Aquila chrysaetos*, as well as the mountain hawk-eagle *Nisaetus nipalensis*, the northern goshawk *Accipiter gentilis*, the peregrine falcon *Falco peregrinus* and other birds of prey. Insects include the *Trechiama solorientis*, *T. nivalis* and *T. montislunnae*, with unique species differentiation between Mt. Gassan, the Asahi Mountain Range and Iide Mountain System.

1.2. Okutone-Okutadami Mountains

1.2.1. Topography and Geography

This is one of the heaviest snowfall areas in Japan, south of the divide between the Pacific Ocean and the Sea of Japan. This has resulted in some unique natural landscapes

impacted by the snow, characterized by avalanche chutes, gullies formed by snow melt and periglacial topography. The Echigo-Sanzan mountain region was formed by significant uplift in a relatively recent geological era and has taken on a steep erosion topography. The Okutone region is at the southern tip of the Echigo Mountain Range has a steep topography with the mountains at a level of around 2,000 m and also has a stepped topography with nivation depressions and high amounts of residual snow even in summer. The monotis fossil bed at the western foot of Mt. Mizunagasawa is the largest in Japan at 100-150m thick and around 1,000m long and has yielded fossils with shells attached.

1.2.2. Vegetation

1) Okutone

The distribution of vegetation is impacted by factors specific to heavy snowfall areas, including avalanches, snow pressure, residual snow and snow melt. Due to the high number of V-shaped valleys, valley forests typical of heavy snowfall regions have also developed. The vegetation in the region includes a Fagetea crenatae area from 850m (Lake Okutone) to around 1,600m above sea level, with Hamamelido-Fagetum crenatae covering the moderate slopes and terraces in the foothills where there are few avalanches. Nanoquercetum has become established in avalanche areas and on fallen slopes. The area above 1,700m is characterized by communities of snow patch vegetation, with many plants endemic to the northern region. Some slopes have beeches with trunks growing down the slope while their tips slant up the slope. Due to the high snowfall and prevailing winter winds, there are hardly any subalpine coniferous forests in the ridge area (pseudo alpine zone).

2) Okutadami

The local vegetation is characterized by primeval *F. crenata* forests, substitutional secondary forests following the logging of *F. cranata*, and Erman's birch *Betula ermanii* forests, as well as subalpine broad-leaved scrub forests of *Quercus crispula* var.

horikawae in the high snowfall areas facing the Sea of Japan. The Echigo-Sanzan Mountains also have a pseudo alpine zone.

1.2.3. Fauna

Due to the diverse topography, geography, climate and vegetation, there are many mammals, birds and insects in the area. There are 7 orders, 15 families and 49 species of mammals confirmed in the region, including large mammals such as the Japanese special natural monument Japanese serow *Capricornis crispus*, as well as the Asiatic black bear *Ursus thibetanus*, the sika deer *cervus nippon* and the Japanese macaque *Macaca fuscata*, and small and medium mammals such as the fox and the Japanese natural monument Japanese dormouse *Glirulus japonicus*. Two rare species are included in the IUCN Red List (the Endo's pipistrelle *Pipistrellus endoi* as EN and the Japanese dormouse as LC).

The many birds, including the golden eagle *Aquila chrysaetos*, designated as a natural monument of Japan, live in a variety of environments, such as the forests, the lakes and the wetlands. There are 90 species of birds confirmed in the Okutone region and over 33 families, 78 species confirmed in the Okutadami region.

2. Proposed OUV

2.1. Heavy Snowfall Environment

There are very few regions in the Northern Hemisphere around 40˚ latitude that have snow depths of over 1m outside of alpine zones. One such area is the northeastern United States. The only mid-latitude area in East Asia to have snow depths of over 1m other than Japan is the Changbai mountain range, spanning across northeastern China and the Democratic People's Republic of Korea. Japan has exceptionally heavy snowfalls for the East Asian region.

In the mountain regions, seasonal winds containing water vapor hit the mountains and are forced upwards, depositing high volumes of snow. The factors contributing to the high snowfall include the abundant supply of water vapor, the strong seasonal winds and the mountain topography encountered by the seasonal winds. The warm Tsushima Current

flows through the Sea of Japan on the windward side of the Japanese archipelago, providing high volumes of water vapor. In winter, Japan is sandwiched between the Siberian High on the continent and the Aleutian Low, creating a very large pressure gradient, a condition very prone to producing seasonal winds. As these damp seasonal winds cross the mountainous backbone of Japan, they produce high volumes of snowfall.

2.1.1. Pseudo Alpine Zone

In this region, there are hardly any tall tree forests above the timber line; while it is the same altitude as a subalpine zone, there are either only a few small subalpine coniferous forests (*Abies mariesii* forest) or none at all, with the area instead covered by deciduous shrubs such as *Acer tschonoskii* and Japanese rowan *Sorbus commixta*, or *Sasa kurilensis*. This kind of subalpine zone without any coniferous forests is called a pseudo alpine zone. The factors that contribute to a pseudo alpine zone are believed to include snow pressure in heavy snowfall areas, strong winds, topographical factors and the impact on the vegetation due to postglacial environmental changes.

Pseudo alpine zone landscapes are mainly found in the mountain areas between the Tohoku and Chubu regions, particularly in the mountain areas of the Tohoku region, such as Mt. Gassan, Mt. Chokai, Mt. Shirakami, Mt. Iwaki, Mt. Asahi, Mt. Iide, as well as areas facing the Sea of Japan, such as the Echigo-Sanzan Mountains and Tanigawa Mountains in the Joetsu Mountains and the northern part of the Northern Alps. Pseudo alpine zones can also been observed in mountainous regions not facing the Sea of Japan, such as Mt. Akita-Komagatake, Mt. Kurikoma and Mt. Adatara in the Ou Mountain Range.

2.1.2. Impact of Snow Gliding on Vegetation

The phenomenon of a layer of fallen snow on a mountain slope sliding under its own weight is called snow gliding. While snow gliding happens slowly, it has immense pressure (snow pressure) and has a major impact on the tree forms and vegetation by continuously applying snow pressure to the ground and plants on the ground.

Snow gliding is propelled by a very high driving force on mountain such as Mt. Iide and Mt. Asahi, due to the great depth of fallen snow as well as the steep mountain topography with its deep valleys. Snow gliding and avalanches are thought to be a causative factor in the formation of the pseudo alpine zones, bereft of subalpine forests.

2.1.3. Snow Patch Communities and Surrounding Vegetation

There are snow patches (nivation hollows) from Mt. Iide to directly under the main peak of Mt. Onnishi. Mountain ridges with snow patches are wind-swept and easily dry out. In summer, they become dry alpine meadows, home to chionophobous plant communities mainly consisting of small shrubs such as *Komebakazura*, *Loiseleuria procumbens* and Japanese stone pine *Pinus pumila*. The areas around snow patches are surrounded by chionophilous plant communities often seen in heavy snowfall regions, such as *Phyllodoce aleutica*, *Trautvetteria caroliniensis* var. *japonica*, *Micranthes japonica* and *Nephrophyllidium crista-galli* sbsp. *japonicum*. The gravel beds in snow patches are fed by spring water and are home to *Saxifraga fusca*, *S. japonica* and *Epilobium fauriei*. The lowest snow patch areas are covered with communities of *T. caroliniensis* var *japonica*, *Moliniopsis japonica* and grasslands of *Thelypteris quelpaertensis*. Distinctive snow patch topography has a concentric distribution of vegetation and a diversity of flora.

2.2. *Fagus crenata* Forests

2.2.1. Phytosociological System of *Fagus crenata* Forests

Fagus crenata regions in Japan have an annual mean temperature of 6-13˚C and an annual precipitation of over 1,300mm. Horizontally, they are cool temperate zones; vertically, they are mountainous regions. Given these climatic conditions, the potential center of distribution is east of the Chubu region and covers a wide expanse. *F. crenata* forests can be divided into five beech associations by a phytosociological comparison of the differences in species composition (Fig.).

A comparison of the number of component species in the forest canopy revealed that the *F. crenata* forest group in the areas facing the Sea of Japan has an average of 2.9 component

species, while the forest group in the areas facing the Pacific Ocean has an average of 10.3 component species. The species composition of the Sasao kurilensis – Fagetum crenatae in the areas facing the Sea of Japan is also distinguished by having significantly fewer regional differences. Consequently, *F. crenata* in the areas facing the Japan Sea have formed almost pure forests. This is thought to be because the high volume of snowfall in winter keeps the soil moist from the beginning of spring through until early summer, providing perfect growing conditions for *F. crenata*.

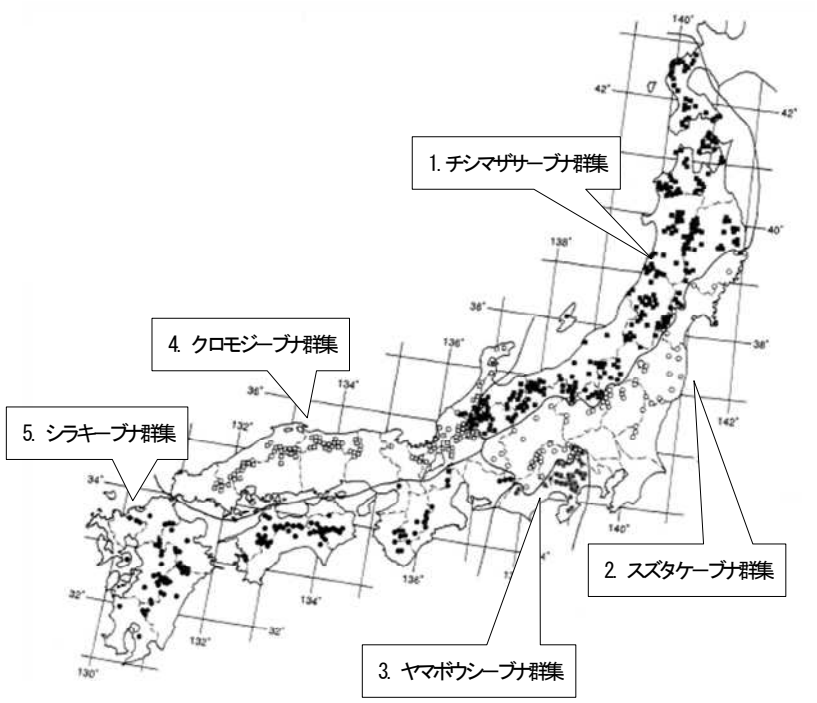


Fig. Distribution of *Fagus crenata* Forests (partially revised from Fukushima et al., 1995)

1. Sasao kurilensis-Fagetum crenatae
2. Sasamorpho-Fagetum crenatae
3. Corno-Fagetum crenatae
4. Lindero umbellatae-Fagetum crenatae
5. Sapio japonici-Fagetum crenatae

2.2.2. Beech Forests in Japan

The *Fagus* has a disjunct distribution throughout three regions of the world: Europe, East Asia and North America. According to Fukushima et al. (2013), East Asian beech forests can be divided into a further three classes. Beeches in Japan and the Republic of

Korea belong to Fagetea crenatae, those in China and Taiwan belong to Litseo elongatae-Fagetea and those in southern Yunnan Province in China and in Vietnam belong to class of evergreen – broadleaved forests (class name and definition are still undecided).

Japan shares many similar features with Ulleung Island in the Republic of Korea. The Korean beech *Fagus multinervis* found on Ulleung Island also belongs to the Fagetea crenatae. This class is characterized by having more deciduous trees than broad-leaved evergreen trees.

While *F. multinervis* forests found on Ulleung Island are similar to the *F. crenata* forests in areas in Japan facing the Sea of Japan in terms of growing into a pure beech forest in a heavy snowfall environment and having a forest floor partially dominated by *Sasa kurilensisi*, the forest floors are mainly covered with ferns. *F. multinervis* forests are not distributed throughout the whole of Ulleung Island; in fact, the whole island is smaller than Shirakami-Sanchi World Heritage Site (17,000ha) or the Oku-Aizu forest ecosystem reserve (83,890ha). This means that Japan has a far more expansive area of pure beech forests.

Like the beech forests on Ulleung Island, European beech *Fagus sylvatica* forests in Europe are similar to the *F. crenata* forests in areas in Japan facing the Sea of Japan in that beech trees occupy most of the tree canopy. However, they differ from the beech forests in Japan in that the species composition of European beech forests is only 1/5 to 1/6 of *F. crenata* forests; they are less diverse than *F. crenata* forests and the ecology has not been impacted by a heavy snowfall environment.

Unlike *F. crenata*, American beech *Fagus grandifolia* almost never grows in pure forests. It is characterized by growing in forests as a constituent species and mixing in with evergreen forests in the northern United States.

F. crenata forests in areas in Japan facing the Sea of Japan extend from southern Hokkaido (Okushiri Island, Kuromatsunai) to the Hokuriku region and include the Shirakami-Sanchi World Heritage Site as well as potential World Heritage sites, such as

Iide, Asahi, Okutone and Okutadami. *F. crenata* forests in areas facing the Sea of Japan are all characterized by a heavy snowfall environment and very little compositional variation.

3. Comparative Cases

3.1. Primeval Beech Forests of the Carpathians and the Ancient Beech Forests of Germany (Germany, Slovakia, Ukraine, 2007/2011, (ix))

The Primeval Beech Forests of the Carpathians and the Ancient Beech Forests of Germany are a serial property comprising fifteen components. They represent an outstanding example of undisturbed, complex temperate forests and exhibit the most complete and comprehensive ecological patterns and processes of pure stands of European beech across a variety of environmental conditions. They contain an invaluable genetic reservoir of beech and many species associated and dependent on these forest habitats.

The Primeval Beech Forests of the Carpathians and the Ancient Beech Forests of Germany are indispensable to understanding the history and evolution of the genus *Fagus*, which, given its wide distribution in the Northern Hemisphere and its ecological importance, is globally significant. These undisturbed, complex temperate forests exhibit the most complete and comprehensive ecological patterns and processes of pure stands of European beech across a variety of environmental conditions and represent all altitudinal zones from seashore up to the forest line in the mountains. Beech is one of the most important elements of forests in the Temperate Broad-leaf Forest Biome and represents an outstanding example of the re-colonization and development of terrestrial ecosystems and communities after the last ice age, a process which is still ongoing. They represent key aspects of processes essential for the long term conservation of natural beech forests and illustrate how one single tree species came to absolute dominance across a variety of environmental parameters.

3.2. Ulleung Island (Republic of Korea)

Ulleung Island is a lava dome in a volcanic archipelago in the Sea of Japan, situated 150km east of the central Korean Peninsula coast. It is a tall and steep volcano that was formed by the hardening of an eruption of sticky lava. The island is surrounded by cliffs and has an elevation of 984m and an area of around 73km^2. Being in the Sea of Japan, it receives heavy snowfalls in winter, like the areas of Honshu facing the Sea of Japan. *F. multinervis* forests are distributed from halfway up the island to its highest point. The forests are nearly pure forest, with some mixing with *Acer pictum* Thunb. subsp. *okamotoanum* and *Tilia insularis*. On the ridgelines, the forests are sometimes mixed with southern Japanese hemlock *Tsuga sieboldii*. While the forest floors are mostly dominated by grass plants such as *Maianthemum dilatatum* and *Acer pictum* Thunb. subsp. *okamotoanum*, some are dominated by *S. kurilensis.* This species is distinctive in *F. crenata* forests in areas in Japan facing the Sea of Japan; it has adapted to heavy snowfall conditions.

3.3. North America

There are two species of *Fagus* in North America: American beech *Fagus grandifolia* and Mexican beech *Fagus mexicana*. *F. grandifolia* is distributed across a wide expanse from 30° to 48° north latitude. Due to its wide distribution area, there is quite a range of mutations in the species. The dominant species in North American summer green forests is more often oak in the *Quercus* genus than beech in the *Fagus* genus. Unlike *F. crenata*, *F. grandifolia* almost never grows in pure forests, instead growing in forests as a constituent species. Due to the wide north-south expanse of the *F. grandifolia* distribution area, the species with which it mixes varies between areas. Particularly in the south, it is characterized by mixing with not only summer green trees, but also with evergreen trees.

There are three main types of mixed *F. grandifolia* forests, from the north to the south of the distribution area.

- *Acer saccharum* - *Fagus grandifolia* forests: The northernmost or highest altitude type of *F. grandifolia* forest. The forest canopy is mainly made up of two species, *A. saccharum* and *F. grandifolia*, with a mix of summer green trees, such as *Quercus, Tilia,*

Ulmus, and *Asesculus*. These *F. grandifolia* forests are the most like *F. crenata* forests. Northern species such as *Maianthemum* and *Dryopteris* occur on the forest floors.

- Mesomorphic mixed forests: Located further south than the former, on plains and low hills from Appalachia to Mississippi, with a tree canopy made up of a wide variety of species as well as *F. grandifolia*, *Liriodendron tulipifera*, *Acer* including *A. saccharum Tilia, Castanea, Aesculus, Quercus*, and *Tsuga*. The proportion of *F. grandifolia* tends to increase on lower slopes and along water courses.

- *Magnolia grandiflora* - *Fagus grandifolia* forests: Found in Georgia, Alabama, Louisiana, Mississippi, Florida and other southern states, these forests differ from the types above in that they characteristically mix with evergreens. The forest canopy is dominated by *F. grandifolia* and *M. grandiflora*, with *L. tulipifera*, *Quercus, Acer, Llex, Liquidambar, Carya* and other species mixed in.

4. Challenges

F. crenata forests in areas in Japan facing the Sea of Japan (Saso kurilensis – Fagetum crenatae) are distinguished by growing in wide expanses of nearly pure forests in areas impacted by heavy snowfalls. They differ in diversity and composition from beech forests in Europe, the United States, China and other places overseas.

Of Japan's *F. crenata* forests, the forests in areas facing the Sea of Japan extend from southern Hokkaido (Okushiri Island, Kuromatsunai) to the Hokuriku region and are all characterized by a heavy snowfall environment and very little compositional variation. These include the Iide and Asahi Mountain Ranges, Okutadami, Okutone and Okunikko. In consideration of these regions facing the Sea of Japan that are covered in *F. crenata* forests, it is difficult to have them listed as a World Heritage site solely on the basis of their being pure*F. crenata* forests, since the Shirakami-Sanchi site is already inscribed.

２）現地説明資料

● ブナ林と多雪環境　中静専門家　－9 月 19 日－

The beech *Fagus* forests in Japan and heavy snowfall environment

1. The beech *Fagus* forests in East Asia and Japan (on the Sea of Japan side)
2. Distribution area and fragmentation rate of Japanese beech *Fagus crenata* forests in Japan
3. Features of Shirakami-Sanchi
4. Heavy snowfall environment in Tohoku region (on the Sea of Japan side)

1. *Fagus* forests in East Asia and Japan (on the Sea of Japan side)

Characteristics of forest vegetation in East Asia

● Three types of temperate deciduous forests which differ in floristic composition

Table 2. Floristic composition of temperate deciduous forest types. Species names with underlines are coniferous species.

	Warm-temperate Deciduous broadleaf forest	Cool-temperate Deciduous broadleaf forest	Mixed broadleaf/ conifer forest
China[1]	*Quercus acutissima*		*Betula costata*
	Q. aliena		*Tilia amurensis*
	Q. dentata		*Quercus mongolica*
	Q. variabilis		*Picea jezoensis*
	Q. serrata		*Abies nephrolepis*
			Pinus koraiensis
Korean Peninsula[2]	*Carpinus tschonoskii*		*Acer mono*
	Quercus acutissima		*Betula chinensis*
	Q. variabilis		*B. schmidtii*
	Q. dentata		*Quercus mongolica*
	Q. serrata		*Carpinus cordata*
			Pinus koraiensis
Japan[3]	*Fagus japonica*	*Fagus crenata*	*Quercus crispula*
	Quercus serrata	*Quercus crispula*	*Abies sachalinensis*
	Carpinus laxiflora	*Acer japonicum*	*Picea jezoensis*
	C. tschonoskii	*Betula maximowicziana*	*Acer mono*
			Tilia japonica

[1] Chiang (1991); [2] Yim (1977); [3] Nozaki & Okutomi (1990).

(Nakashizuka & Iida 1995)

The disturbance regimes vary among the different forest types. Small-scale treefall gaps prevail in cool-temperate deciduous broadleaf forests.

Table 4. Summary of deciduous temperate forest types

	Warm-temperate Deciduous broadleaf forest	Cool-temperate Deciduous broadleaf forest	Mixed broadleaf/ conifer forest
Dominants	*Quercus*	*Fagus*	*Quercus* Conifers
Species richness	High	Low	High
Disturbances	Treefall gaps Fire	Treefall gaps	Treefall gaps Fire Big blowdowns

(Nakashizuka & Iida 1995)

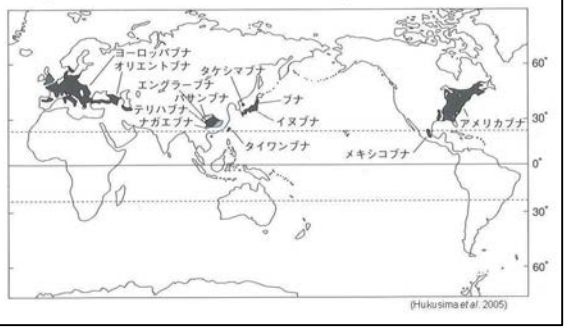
→The cool-temperate deciduous broadleaf forests dominated by *Fagus* are distributed only in the limited areas of East Asia.

Features of *Fagus* forests

- *Fagus* mixes in with evergreen species in southern part of the distribution area, while it mixes in with other deciduous species in central to northern parts of the distribution area.
- *Fagus sylvatica*, *F. multinervis*, and *F. crenata* are almost monodominant in northern forests, as the portion of *Fagus* increases toward north.
- *Fagus* tends to contain key species for forest ecosystems, as *Fagus* species often dominate the forests.

Fagus in the world

- 11 *Fagus* species are distributed from warm to temperate zones in the northern hemisphere.
- *Fagus* forests occur under conditions of relatively humid oceanic climate.



(Hukusima *et al.* 2005)

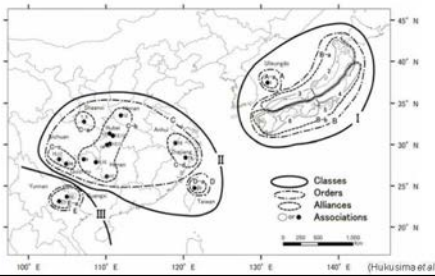
Fagus forests in East Asia

The phytosociological system of *Fagus* in East Asia is classified into 3 broad categories.

Class I : *Fagus crenata* forests in Japan and *F. multinervis* forests in Korea (Ulleung Island). The forests contain many deciduous species.

Class II : *Fagus* forests in central China and northern Taiwan. The forests contain many evergreen species.

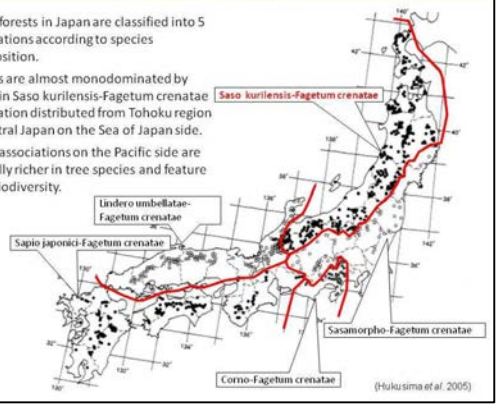
Class III : *Fagus* forests in southeast Yunnan Province, China. The forests contain many evergreen species, as this area belongs to subtropical zone.



(Hukusima *et al.* 2013)

Fagus forests in Japan

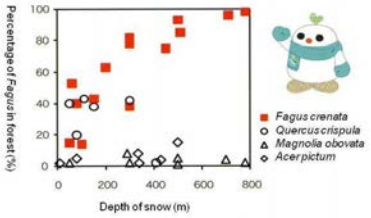
- *Fagus* forests in Japan are classified into 5 associations according to species composition.
- Forests are almost monodominated by *Fagus* in Saso kurilensis-Fagetum crenatae association distributed from Tohoku region to central Japan on the Sea of Japan side.
- *Fagus* associations on the Pacific side are basically richer in tree species and feature high biodiversity.



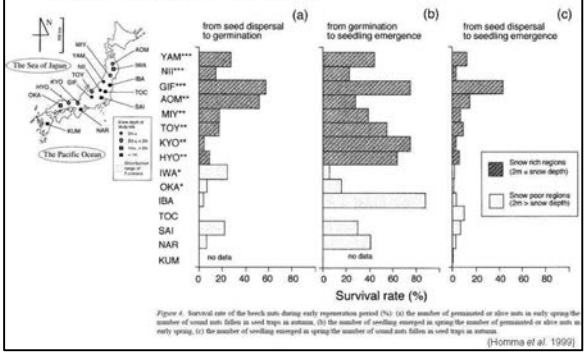
(Hukusima *et al.* 2005)

- Intensive dominance of *Fagus* in heavy snowfall region

Relationship between snow accumulation and dominance of *Fagus*



- Survival rate of the beech nuts during winter is higher in areas with heavy snowfall than in areas with little snowfall



(Homma *et al.* 1999)

Summary of *Fagus* forests in Japan

- *Fagus* forests on the Sea of Japan side are considered to be a forest vegetation that has adapted to heavy snowfall environment. Such *Fagus* forests are unique in the world.

(井上邦彦氏撮影)

2. Analysis of the distribution area and fragmentation rate of *Fagus* forests in Japan

The status of *Fagus* forests in each area was evaluated by quantitative analysis of their scale, coverage rate, and continuity.

Sort out areas on the basis of mountain masses

↓

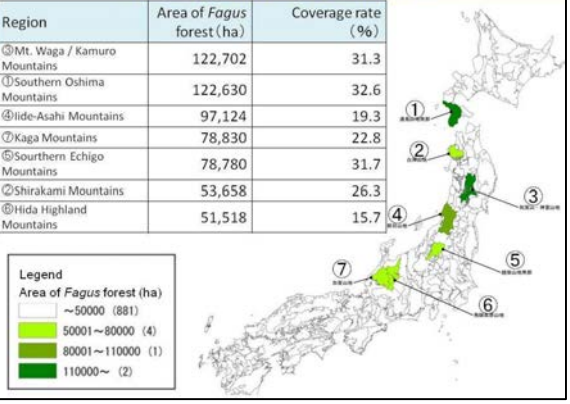
Extract areas with *Fagus* forests which have certain scale and high coverage rate

↓

Estimate fragmentation rate caused by forest roads (overlap rate of *Fagus* forests and forest roads)

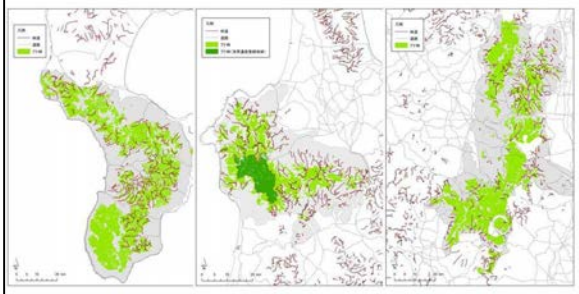
Scale of *Fagus* forests and coverage rate

Region	Area of *Fagus* forest (ha)	Coverage rate (%)
③Mt. Waga / Kamuro Mountains	122,702	31.3
①Southern Oshima Mountains	122,630	32.6
④Iide-Asahi Mountains	97,124	19.3
⑦Kaga Mountains	78,830	22.8
⑤Sourthern Echigo Mountains	78,780	31.7
②Shirakami Mountains	53,658	26.3
⑥Hida Highland Mountains	51,518	15.7

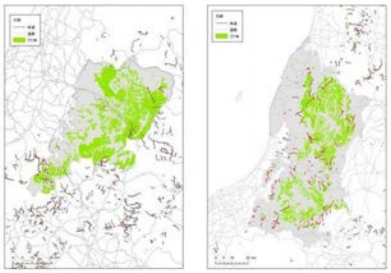


Fagus forests and distribution of roads

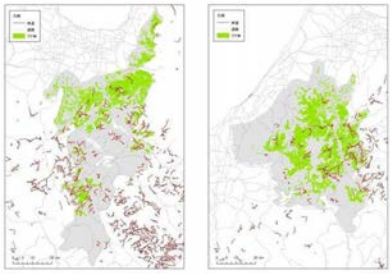
Southern Oshima Mountains　Shirakami Mountains　Mt. Waga/Kamuro Mountains



Sourthern Echigo Mountains　Iide-Asahi Mountains



Hida Highland Mountains　Kaga Mountains



Summary of *Fagus* forests in each area

Area	*Fagus* forest Area (No. of cells)	Rate of fragmentation by roads(%)	Rate of continuous forest(%)	
Shirakami Mountains	53,588	3.58	96.42	Continuous *Fagus* forests with low fragmentation rate.
Shirakiami-Sanchi (World Heritage Site)	14,514	0.01	99.99	
Southern Oshima Mountains	122,593	5.04	94.96	Large-scale forests with less continuity.
Mt. Waga/Kamuro Mountains	124,016	2.39	97.61	
Iide-Asahi Mountains	97,190	1.10	98.90	Continuous smaller-scale forests with low fragmentation rate.
Sourthern Echigo Mountains	78,530	1.33	98.67	
Hida Highland Mountains	51,596	2.84	97.16	Smaller-scale forests with less continuity
Kaga Mountains	78,865	2.48	97.52	

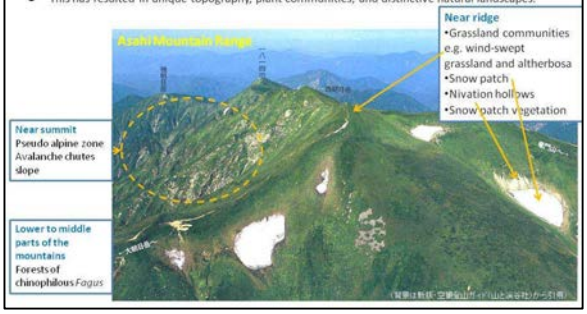
3. Features of Shirakami-Sanchi

Video picture

4. Heavy snowfall environment from Tohoku region to central Honshu on the Sea of Japan side

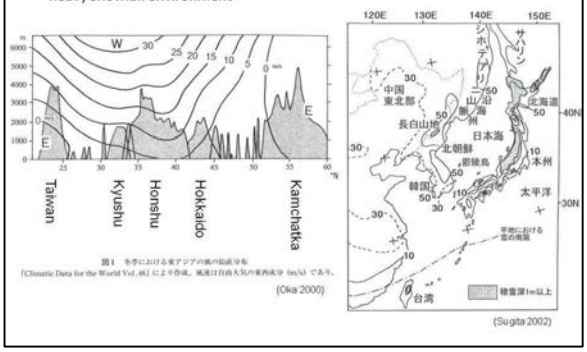
Heavy snowfall environment

- The area from Tohoku region to central Honshu is one of the regions with the heaviest snowfall and strong winds in the world.
- This has resulted in unique topography, plant communities, and distinctive natural landscapes.



Heavy snowfall environment

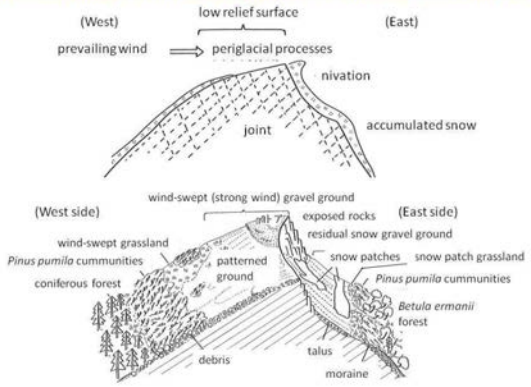
- Jet stream (westerlies) and humid atmosphere on the Sea of Japan result in heavy snowfall environment



(Oka 2000)

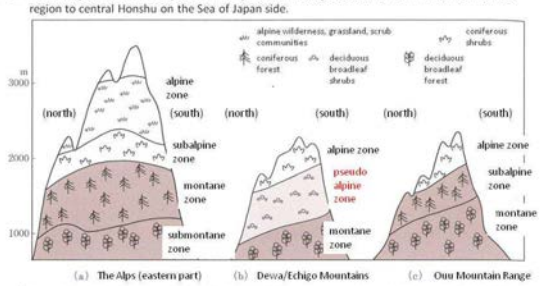
(Sugita 2002)

Asymmetry ridges formed by strong wind and snowfall environment



Pseudo Alpine Zone

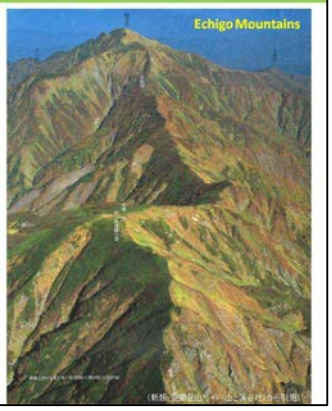
- The pseudo alpine zone is a kind of subalpine zone (same altitude as subalpine zone) without any subalpine coniferous forests, with the area instead covered by deciduous shrubs or dwarf bamboo floor. This kind of zone was established by heavy snowfall in postglacial period.
- Pseudo alpine zone landscapes are mainly found in heavy snowfall environments from Tohoku region to central Honshu on the Sea of Japan side.



Comparison of vegetation zones in the Alps and Japanese mountains (As for the Alps: Polunin & Walters, 1985; partially modified) (Kikuchi 1997)

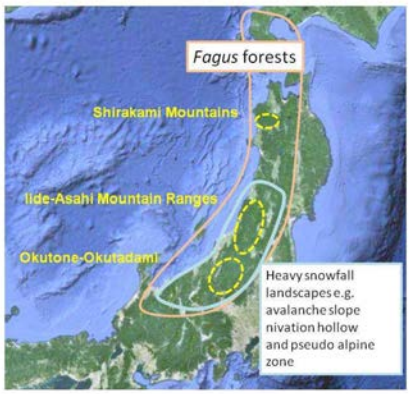
Avalanche slopes

- Snow gliding (slow snow sliding) and avalanches occur on mountain slopes, forming avalanche landforms and unique vegetation landscapes.



Snow patch communities and surrounding vegetation

- Residual snow is observed until summer near the ridges. Nivation hollows are found above the residual snow area (snow patches). Due to time lag in snow melt and excessive soil moisture, snow patch vegetation appears surrounding the snow patches.
- Due to strong winds, there are grasslands such as wind-swept grasslands in the ridges and flat terrains in the ridge areas.



Future directions

- Possible options
  - no action
  - nominate as a serial extension of Shirakami-Sanchi
  - nominate as a new site focused on unique heavy snowfall environment
  - renominate the whole site including Shirakami-Sanchi, with the theme of heavy snowfall and *Fagus* forests