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ARTICLE

Result of study on developing forest seed region in Mongolia

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Abstract: *In foreign countries, motor roads and railroads are usually used as borders of forest seed regions. In the case of Mongolia, this method is not suitable in view of the sparse population, large distribution area of forests and the huge territory of the country. Therefore, this study used topographical features to determine the borders of the seed regions. Satellite images in combination with Digital Elevation Model (DEM) make it possible to define rivers, streams and mountain ridges as the borders of forest seed regions. Overall, we identified 19 seed regions for Siberian larch and 12 regions for Scots pine, 9 regions for Siberian pine, 6 regions for Siberian fir and 9 seed regions for Siberian spruce forests. Due to a lack of genetic-selection studies in Mongolia, these proposed forest seed regions can be considered as a preliminary effort with an opportunity to be updated and improved based on more detailed research results. The forest seed regions and maps will play important role as fundamental material for establishing a permanent forest seed supply based on genetic-selection characteristics of the forests in different regions in Mongolia.*

Keywords: *Seed; Region; Pine; Larch; Siberian pine; Siberian fir; Siberian spruce;*

INTRODUCTION

The forestry sector in Mongolia is rapidly changing, including reforestation and restoration activities which been broadening in all aspects. Therefore, it is vitally important to establish scientific knowledge and understanding of the hereditary and genetic characteristics of the main forest-forming tree species for certain forest regions to ensure successful reforestation and forest restoration efforts. Hence, it is vital to determine forest seed regions in order to utilize geographic difference in adaptation and productivity of trees in order to grow high productivity forests which can withstand adverse environmental factors.

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Several previous researches, including Milyutin et al., (1988) produced preliminary forest seed zoning under the framework of Mongolian-Russian Joint Biological Complex Expeditions conducted in 1981-1990 and they identified 13 seed regions for Siberian larch and 4 seed regions for Scotch pine forests respectively [13]. These studies were notable in terms of their significance in improving the quality of reforestation work, enabling experimental research to use seeds from geographically different regions, and establishing permanent seed stands based on the genetic-selection process in each district [17]. In addition, the study into internal modification of larch species in eastern Khentii along with research to identify parameters of larch seed quality have helped determined the best regions (forest seed zoning) to transplant seeds across. The joint expeditions also reported that the difference and modification in the morphological characteristics of larch populations were dependent on the growth conditions, and distribution of populations. What was new about this study was that it was able to determine the larch seed districts in the forest-vegetation zone of Khentii, where *Larix sibirica, L. daurica*, and *L. chekanowskii* are present [1,5,6,7,9,10,11,12]. The main objective of this study is to develop the seed region mapping of Mongolia's coniferous forests based on genetic-selection characteristics. For this purpose, we aim to identify seed regions for coniferous trees including Siberian larch (*Larix sibirica* Ldb.), Scots pine (*Pinus sylvestris* L.); Siberian pine (*Pinus sibirica* Du Tour.), Siberian fir (*Abies sibirica* Ldb.), and Siberian spruce (*Picea obovata* Ldb.)

MATERIALS AND METHODS

The basic units of the seed region are the identical genetic origin and growth conditions, which differ from neighboring regions which is representative of a given provenance region in terms of altitude, climate, soil and vegetation characteristics. *Local seeds* are those that have been collected from forests within the border of the same seed region; and *seeds from other regions* refer to those that have been collected from other seed regions. The following materials, information and sources are used in developing seed regions and their mapping.

1. Digital elevation model of SRTM satellite data with 30 m accuracy
2. Satellite maps Google Earth
3. Meteorological data of study areas
4. Forest inventory reports, materials, and maps
5. Specialized maps
   I. Topographic map
   II. Digital elevation model
   III. Mountain slope map
   IV. Soil map
   V. Vegetation map
   VI. Forest distribution map

The forest distribution map (shape file) with descriptions of 464,323 stands was developed by the Forest Research Development Center (FRDC) of the Ministry of Environment and Tourism (MET). These shape files had information on species composition, tree species, and ecological and geographical data of the forest stand and compartments. The digital elevation model, different satellite images, specialized thematic maps and field survey results on soil and vegetation characteristics have been used as additional materials.

A digital elevation model was used with Surpace to define aspects. Spatial overlapping analysis has been conducted to prepare and extract information from specialized maps [3,4,13,14].

Based on the experiences from other countries, motor roads and railroads are usually used as borders of the forest seed regions

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[16]. In the case of Mongolia, this method is not suitable due to the sparse population, large distribution area of forests and the large territory. Therefore, we used topographical features to determine borders of the seed regions. Topographical maps visibly denote the borders using river, stream and mountain ridges as border areas [2,8,15,16].

During the field survey, an inventory of seed stands and studies of vegetation and soil types were conducted, which enabled to produce detailed seed region maps. Digital Elevation Models with 30m resolution and Satellite Images (Google Earth, Landsat) were used in the map processing.

RESULTS AND DISCUSSION

The basic unit of the seed regions is the forest seed region, which is characterized by similar soil and vegetation characteristics, moisture condition, and index of continent to produce a population with similar genetic materials (within the distribution limit of the certain species of tree).

Mongolian forests are mountain forests with high altitudinal variation and dry growth conditions, hence, seed quality of the main tree species have been declining recently. For this reason, we did not divide seed regions into sub-regions. It is required to use seeds collected from local or neighboring regions/populations for the tree propagation and reforestation activities.

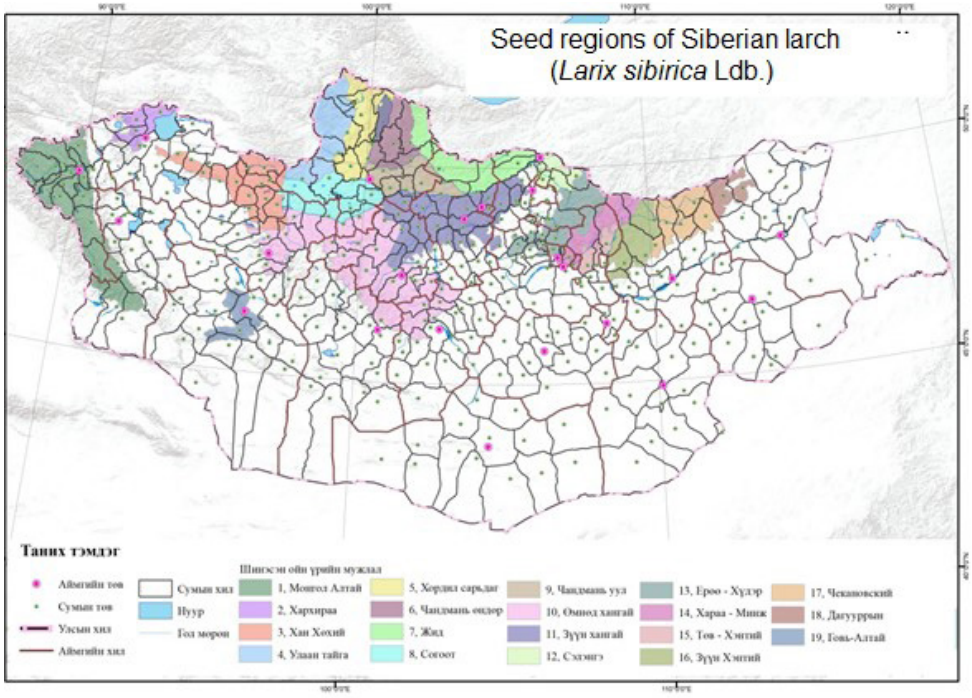

Figure 1. Siberian larch (Larix sibirica Ldb.) seed regions: 1. Mongol - Altai; 2. Kharkhiraa, 3. Khan Khokhii; 4. Ulaan taiga; 5. Khoridol Saridag; 6. Chandmani - Ondor; 7. Jid; 8. Sogoot; 9. Chandmani Uul; 10. Southern Khangai; 11. Eastern Khangai; 12. Selenge; 13. Yuroo - Khuder; 14. Kharaa-Minj; 15. Central Khentii; 16. Eastern Khentii; 17. Chekanowski; 18. Dahuur; 19. Gobi - Altai

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The research results identified 19 seed regions for Siberian larch (*Larix sibirica* Ldb.), Dahurian larch (*Larix dahurica* Turcz.), and Chekanowskii larch (*Larix chekanowskii* Szaf.); 12 regions for Scots pine (*Pinus sylvestris* L.); 9 regions for Siberian pine (*Pinus sibirica* Du Tour.); 6 regions for Siberian fir (*Abies sibirica* Ldb.), and; 9 seed regions for Siberian spruce (*Picea obovata* Ldb.) forests and a map with a scale of 1:1 000 000 was developed which will serve as the base material for further seed management efforts with emphasis on conservation of forest genetic resources and tree breeding.

Seeds collected from the plain (steppe) forests can be used for almost all forest regions, however, seeds collected from mountainous regions can only be used within a 200-400 m range from the original altitude.

We identified 19 seed regions for Siberian larch and 12 regions for Scots pine, 9 regions for Siberian pine, 6 regions for Siberian fir and 9 seed regions for Siberian spruce forests. Each seed region is presented with information on possible regions to transfer seeds for transplanting, environment-climate conditions and regional forest characteristics, given in Tables 1-5.

Due to a lack of genetic-selection studies in Mongolia, these proposed forest seed regions can be considered a preliminary effort with the possibility to be updated and improved in the future, based on more detailed research results. These forest seed regions can be used as fundamental material for establishing a permanent forest seed supply, based on genetic-selection characteristics of the forests in different regions in Mongolia.

Table 1. Seed regions of Siberian larch forests

№	Seed region	Vegetation period, day	Average annual air temperature, °C	Sum of the temperature above 5°C	Total annual precipitation, mm	Moisture coefficient	Average air temperature, °C [Conrad's index of continentally, %]
1	Mongol - Altai	131	-0.34	2147.1	107.0	0.65	-21.4 (17.3). [89]
2	Kharkhiraa	137	-1.75	2641.6	140.9	0.60	-30.8 (21.2). [89]
3	Khan Khokhii	129	-1.70	1956.9	191.4	1.32	-28.5 (17.6). [79]
4	Ulaan taiga	123	-5.37	1592.4	272.2	1.96	-30.1 (15.2). [87]
5	Khoridol Sari-dag	121	-4.17	1490.9	238.1	2.1	-25.9 (14.5). [80]
6	Chandmani - Ondor	127	-2.94	1719.5	261.1	1.96	-23.5 (15.2). [82]
7	Jid	143	0.16	2119.9	309.6	1.46	-23.3 (19.4). [79]
8	Sogoot	141	-2.75	1934.8	245.0	1.57	-26.3 (16.7). [80]
9	Chandmani Uul	143	-0.54	2247.1	305.9	1.63	-23.7 (17.6). [79]
10	Southern Khangai	152	-1.62	1861.8	261.9	1.78	-22.9 (15.4). [69]

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11	Eastern Khan-gai	168	0.02	2124.9	314.3	1.68	-21.1 (18.5). [74]
12	Selenge	127	-1.33	1569.5	311.5	1.45	-27.8 (19.7). [94]
13	Yuroo - Khuder	139	-0.32	1962.8	297.7	1.42	-24.6 (19.4). [85]
14	Kharaa - Minj	132	-1.31	1929.0	312.6	1.94	-22.8 (16.8). [76]
15	Central Khentii	129	-1.19	1840.8	292.2	1.91	-22.6 (16.4). [73]
16	Eastern Khentii	148	-1.55	2149.9	332.9	1.81	-20.1 (17.9). [76]
17	Chekanovski	156	0.11	2470.9	319.8	1.55	-19.8 (19.0). [76]
18	Daguur	154	0.38	2429.7	334.9	1.59	-19.6 (19.5). [74]
19	Gobi-Altai	168	1.62	2810.1	142.0	0.91	-22.5 (21.6). [75]

**Source: Meteorological and Environmental Monitoring Agency*

Table 2. Siberian larch (Larix sibirica Ldb.) seed region covers the following soums in certain aimag territory

Seed region		Seed region includes the following territory of soums
No	Name	
1	Mongol - Altai	Nogoonnuur, Ulaankhus, Tsengel, Sagsai, Altan Tsogts, Buyant, Altai, Tolbo, Deluun soums Bayan-Olgii aimag; Bulgan, Uyench soums, Khovd aimag;
2	Kharkhiraa	Davst, Sagil, Turgen, Taryalan soums, Uvs aimag;
3	Khan Khokhii	Malchin, Khyargas, Tsagaan Khairkhan, Ondor Khangai, Baruunturuun, Zuunkhangai soums Uvs aimag; Tes, Bayantes, Asgat, Bayan Khairkhan, Songino, Tudevtei, Nomrog, Tsetsen Uu soums, Zavkhan aimag;
4	Ulaan taiga	Tsagaannuur, Renchynlkhumbe, Ulaan Uul, Bayanzurkh, Tsagaan Uul, Tset-serleg soums, Khovsgol aimag;
5	Khoridol Saridag	Renchynlkhumbe, Khankh, Khatgal, Arbulag, Alag Erdene soums, Khvsgol aimag;
6	Chamdmani - Ondor	Khankh, Tsagaan Uur, Chandmani Ondor, Alag Erdene, Erdenebulgan, Tünel soums, Khovsgol aimag;
7	Jid	Tsagaan Uur, Erdenebulgan soums, Khovsgol aimag; Teshig, Selenge soums, Bulgan aimag; Tushig, Tsagaan Nuur soums, Selenge aimag
8	Sogoot	Tsetserleg, Tsagaan Uul, Burentogtokh, Tomorbulag, Shine Ider soums, Khovsgol aimag; Ikh Uul, Telmen soums, Zavkhan aimag;
9	Chandmani - Uul	Tunel, Erdenebulgan, Tosontsengel, Ikh Uul, Taryalan soums, Khovsgol aimag; Khutag Ondor soums, Bulgan aimag;

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10	Southern Khangai	Yaruu, Ider, Tosontsengel, Ikh Uul, Tsagaan Khairhan, soums, Zavkhan aimag; Jargalant, Galt soums, Khovsgol aimag; Tsakhir, Taryat, Jargalant, Khangai, Chuluut, Ikhtamir, Erdenemandal, Tovshruulekh, Tsenkher, Bulgan, Tsetserleg, Khotont soums, Arkhangai aimag; Chuluut, Erdenetsogt soums, Bayankhongor aimag; Bat Olziit, Khujirt, Kharkhorin, Uyanga, Zuunbayan Ulaan soums, Bayankhongor aimag;
11	Eastern Khangai	Rashaant soum, Khovsgol aimag; Tsetserleg, Erdenemandal, Khairkhan, Battsengel, Olziit soums, Arkhagai aimag; Bayan Agt, Khutag Ondor, Bugat, Saikhan, Mogod, Khishig Ondor, Burug Khangai, Orkhon, Khangal soums, Bulgan aimag; Bayan Ondor, Jargalant soums, Orkhon aimag; Baruubüren, Khushaat, Sant soums, Selenge aimag;
12	Selenge	Shaamar, Altanbulag, Khuder, Yüroo soums, Selenge aimag;
13	Yuroo - Khuder	Yuroo, Khuder, Bugant, Bayangol, Mandal soums, Selenge aimag; Khongor, Shariin Gol soums, Darkhan Uul aimag; Jargalant, Bornuur, Bayanchandmani, Batsumber soums, Tov aimag;
14	Kharaa - Minj	Ulaanbaatar, Erdene, Mongonmorti soums, Tov aimag; Batshireet soum, Khentii aimag;
15	Central Khentii	Erdene, Mongonmorti, Bayandelger soums, Tov aimag;
16	Eastern Khentii	Tsenkhermandal, Omnodelger, Batshireet soums, Khentii aimag;
17	Checanovski	Omnodelger, Binder, Bayan Adarga, Norovlin, Dadal soums, Khentii aimag; Bayan Uul, Tsagaan Ovoo soums, Dornod aimag;
18	Daguur	Bayan Uul, Bayandun soums, Dornod aimag;
19	Gobi - Altai	Jargalan, Khaliun, Togrog soums, Gobi - Altai aimag;

Table 3. Seed regions of Scotch pine forests

№	Seed region	Vegetation period, day	Average annual air temperature, °C	Sum of the temperature above 5°C	Total annual precipitation, mm	Moisture coefficient	Average air temperature, °C [Conrad's index of continentally, %]
1	Tsagaan - Uur	132	-3.9	1848.6	250.7	2.54	-30.1 (16.4). [89]
2	Jid	143	0.16	2119.9	309.6	1.46	-23.3 (19.4). [79]
3	Burengiin Nuruu	149	-0.01	1997.1	318.0	1.61	-22.5 (19.3). [79]
4	Bayan - Khan uul	151	0.52	1718.0	275.8	1.23	-23.2 (20.6). [85]
5	Yuroo - Khuder	133	-1.01	1565.0	334.3	1.55	-26.8 (19.4). [91]
6	Kharaa Minj	146	-0.34	2050.5	292.2	1.45	-23.2 (19.1). [81]
7	Shariin Gol	139	-0.58	1902.5	298.7	1.39	-26.2 (19.8). [89]
8	Jargalant	163	0.11	2301.2	299.0	1.49	-21.6 (18.6). [75]

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9	Bayanchandmani	159	0.01	2184.6	277.1	1.47	-20.0 (17.7). [71]
10	Eastern Khentii	162	0.03	2422.1	286.9	1.35	-21.5 (19.5) [82]
11	Ereenii Nuruu	178	-0.21	2363.8	322.8	1.49	-20.6 (18.5). [77]
12	Khalkh Gol	183	0.01	2672.7	350.2	1.46	-28.9 (20.9). [98]

*Source: Meteorological and Environmental Monitoring Agency

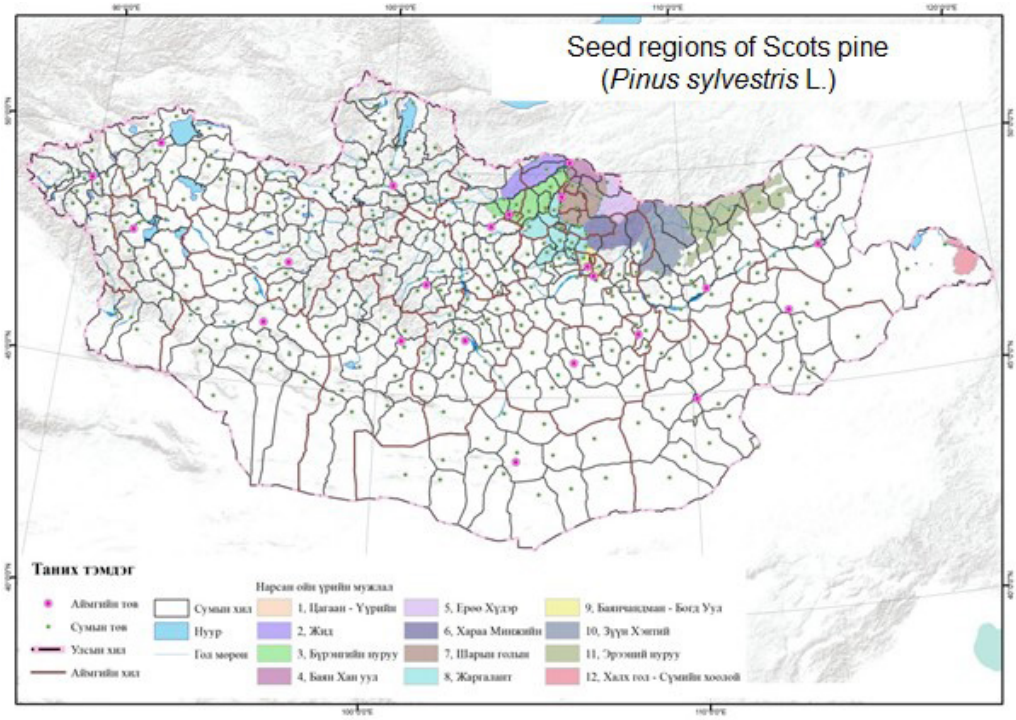

Figure 2. Scots pine (Pinus sylvestris L) seed regions: Tsagaan - Uur; 2. Jid; 3. Burengiin Nuruu; 4. Bayan - Khan Uul; 5. Уьroo - Khuder; 6. Kharaa - Minj; 7. Shariin Gol; 8. Jargalant; 9. Bayanchandmani; 10. Eastern Khentii; 11. Ereenii Nuruu; 12. Khalkh Gol

Table 4. Scots pine (Pinus sylvestris L.) seed region covers the following soums in certain aimag territory

Seed region name		Seed region includes the following territory of soums
No	Name	
1	Tsagaan - Uur	Tsagaan - Uur soum, Khovsgol aimag
2	Jid	Khutag-Ondor, Selenge, Khilgant soums, Bulgan aimag; Tushig, Tsagaannuur soums, Selenge aimag.
3	Burengiin Nuruu	Bugat, Saikhan, Khilgant soums, Bulgan aimag; Bayan Ondor, Jargalant soum, Orkhon aimag; Baruunburen, Sant, Khushaat, Zuunburen soums, Selenge aimag.
4	Bayanhan - Uul	Shaamar, Altanbulag soums, Selenge aimag.

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5	Yuroo - Khuder	Yuroo, Khuder, Bugant soums, Selenge aimag.
6	Kharaa - Minj	Mandal soum, Selenge aimag; Batsumber soum, Tov aimag; Batshireet soum, Khentii aimag;
7	Shariin Gol	Jargalant, Yeruu, Bugant, Bayangol soums, Selenge aimag; Khongor, Shariin Gol soums, Darkhan aimag;
8	Jargalant	Jargalant, Bornuur, Chandmani, Batsumber soums, Tov aimag;
9	Bogdkhan Uul	Bogdkhan uul, Ulaanbaatar
10	Bayan- Adarga	Batshireet, Omnodelger, Bayan Adarga, Dadal soums, Khentii aimag;
11	Yuroonii nuruu	Binder, Bayan Adarga, Norovlin, Dadal soums, Khentii aimag; Bayan Uul, Bayandun soums,Dornod aimag;
12	Sumiin Khooloi	Khalkh Gol soum, Dornod aimag;

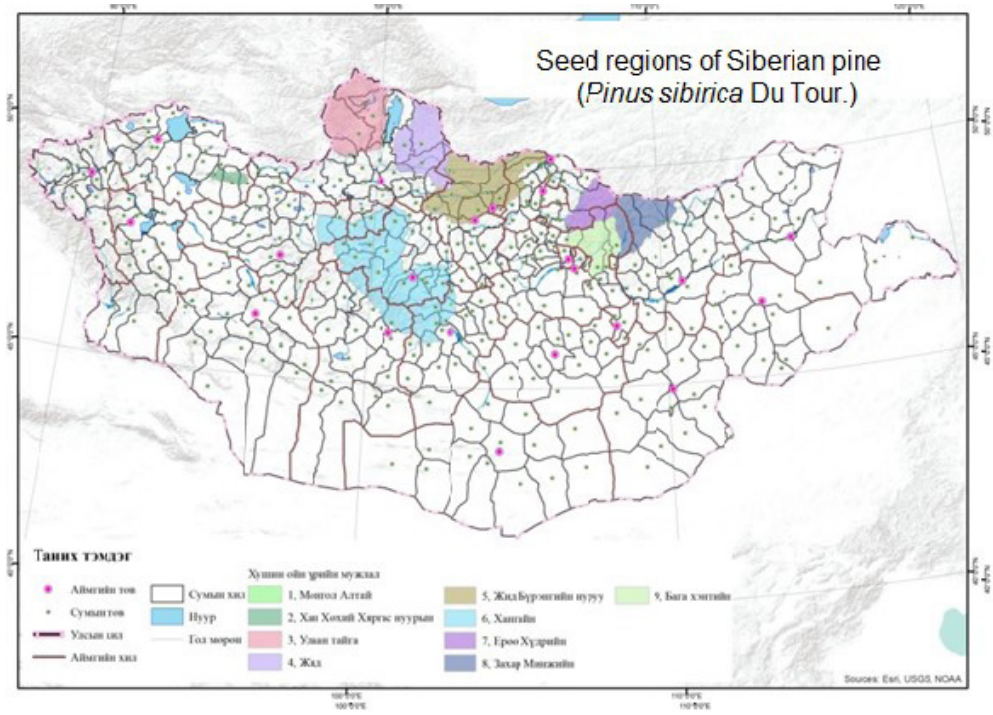

Figure 3. Siberian pine (Pinus sibirica Du Tour.) seed regions: 1. Mongol - Altai; 2. Khan Khokhii-Khyargas lake; 3. Ulaan taiga; 4. Jid; 5. Jid Burengiin Nuruu; 6. Khangain Nuruu; 7. Yuroo - Khuder; 8. Zakhar-Minj; 9. Baga Khentii

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Table 5. Seed regions of Siberian pine

№	Seed region	Vegetation period, day	Average annual air temperature, °C	Sum of the temperature above 5°C	Total annual precipitation, mm	Moisture coefficient	Average air temperature, °C [Conrad's index of continentally, %]
1	Mongol - Altai	131	-0.34	2147.1	107.0	0.65	-21.4 (17.3). [89]
2	Khan Khokhii - Khyargas lake	137	-1.75	2641.6	140.9	0.60	-30.8 (21.2). [89]
3	Ulaan taiga	123	-5.37	1592.4	272.2	1.96	-30.1 (15.2). [87]
4	Jid	143	0.16	2119.9	309.6	1.46	-23.3 (19.4). [79]
5	Jid Burengiin Nuruu	149	-0.01	1997.1	318.0	1.61	-22.5 (19.3). [79]
6	Khangai Nuruu	139	-0.32	1962.8	297.7	1.42	-24.6 (19.4). [85]
7	Yuroo - Khuder	133	-1.01	1565.0	334.3	1.55	-26.8 (19.4). [91]
8	Zakhar Minj	146	-0.34	2050.5	292.2	1.45	-23.2 (19.1). [81]
9	Baga Khentii	132	-1.31	1929.0	312.6	1.94	-22.8 (16.8). [76]

**Source: Meteorological and Environmental Monitoring Agency*

Table 6. Siberian pine (Pinus sibirica Du Tour.) seed region covers the following soums in certain aimag territory

Seed region name		Seed region includes the following territory of soums
No	Name	
1	Mongol-Altai	Tsengel soum, Bayan-Olgii aimag;
2	Khan Khokhii Khyargas Nuur	Tsagaan Khairkhan, Ondorkhangai, Zuunkhangai soums, Uvs aimag; Tes soum, Zavkhan aimag;
3	Ulaantaiga	Tsagaannuur, Renchinlkhumbe, Ulaan Uul, Bayanzurkh, Tsetserleg soums, Khovsgol aimag;
4	Jid	Tsagaanuur, Chandmani Ondor, Erdenebulgan, Taryalan soums Khovsgol aimag; Teshig soum, Bulgan aimag;
5	Jid - Burengiin Nuruu	Bayan Agt, Saikhan, Khutag Ondor, Selenge, Teshig soums, Bulgan aimag; Baruunburen, Tushig, Tsagaannuur soums, Selenge aimag;
6	Khangai	Tosontsengel soum, Zavkhan aimag; Jargalant, Galt soums Khovsgol aimag; Tsakhir, Taryat, Khangai, Chuluut, Ikh Tamir, Jargalant, Bulgan, Tsenkher, Tovshruulekh soums, Arkhangai aimag; Bat Olziit, Khujirt, Uyanga soums, Ovorkhangai aimag;
7	Yuroo - Khuder	Yuroo, Khuder soums, Selenge aimag;
8	Zakhar - Minj	Mongonmorti soum, Töv aimag; Tsenkhermandal, Batshireet, Binder soums, Khentii aimag;
9	Baga Khentii	Ulaanbaatar, Erdene, Bayandelger soums, Tov aimag;

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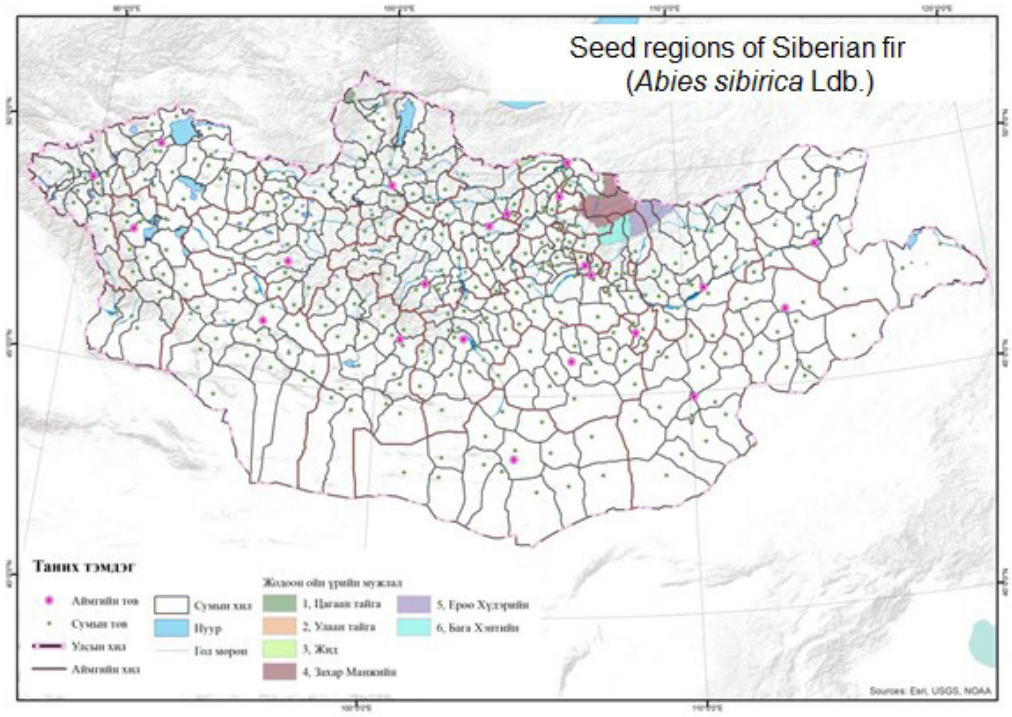

Figure 4. Siberian fir (Abies sibirica Ldb.) seed regions: 1. Tsagaan Taiga; 2. Ulaan Taiga; 3. Jid; 4. Zakhar Minj; 5. Yөroo - Khuder; 6. Baga Khentii

Table 7. Seed regions of Siberian fir forests

№	Seed region	Vegetation period, day	Average annual air temperature, °C	Sum of the temperature above 5°C	Total annual precipitation, mm	Moisture coefficient	Average air temperature, °C [Conrad's index of continentally, %]
1	Tsagaan taiga	121	-6.67	1536.3	218.3	1.58	-34.4 (15.7). [97]
2	Ulaan taiga	123	-5.37	1592.4	272.2	1.96	-30.1 (15.2). [87]
3	Jid	143	0.16	2119.9	309.6	1.46	-23.3 (19.4). [79]
4	Zakhar Minj	133	-1.01	1565.0	334.3	1.55	-26.8 (19.4). [91]
5	Yüroo - Khuder	146	-0.34	2050.5	292.2	1.45	-23.2 (19.1). [81]
6	Baga Khentii	132	-1.31	1929.0	312.6	1.94	-22.8 (16.8). [76]

**Source: Meteorological and Environmental Monitoring Agency*

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Table 8. Siberian fir (Abies sibirica Ldb.). seed region covers the following soums in certain aimag territory

Seed region		Seed region includes the following territory of soums
№	Name	
1	Tsagaan taiga	Tsagaannuur soum, Khovsgol aimag;
2	Ulaan taiga	Renchinlkhümbe soum, Khovsgol aimag;
3	Jid	Tushig, Tsagaannuur soum, Selenge aimag;
4	Yuroo - Khuder	Yuroo, Khuder, Bugant, Mandal soums, Selenge aimag;
5	Zakhar - Minj	Mandal soum, Selenge aimag; Mongnmorti soum, Tov aimag; Batshireet soum, Khentii aimag;
6	Baga Khentii	Mongonmorti soum, Tov aimag;

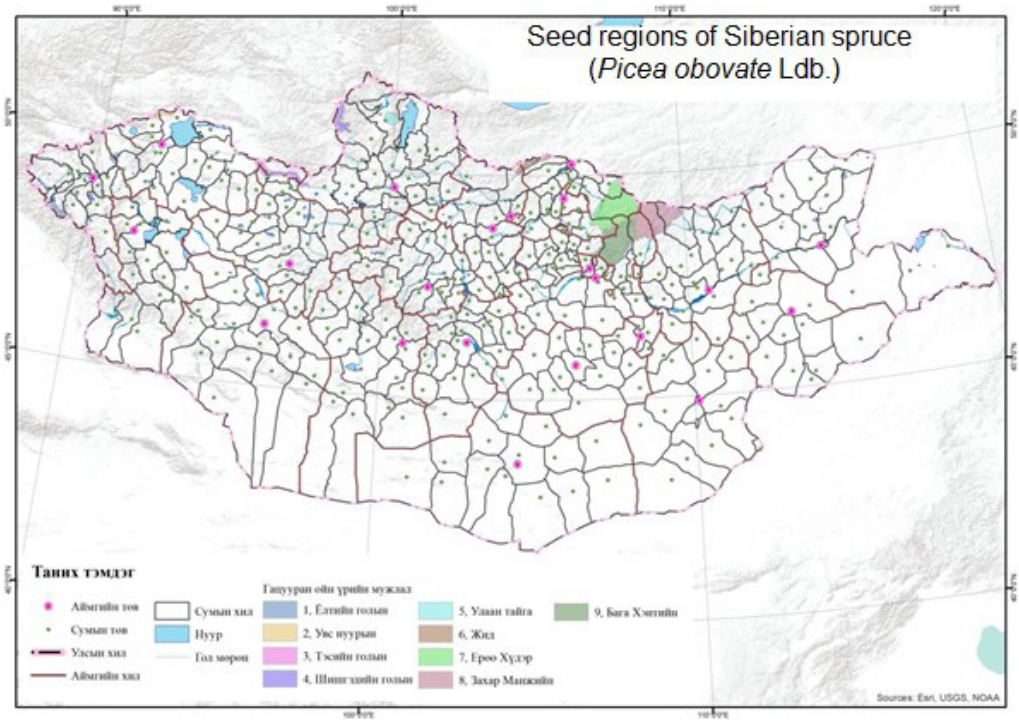

Figure 5. Siberian spruce (Picea obovate Ldb.) seed regions: 1. Yoltiin Gol; 2. Uvs Nuur; 3. Tesiin Gol; 4. Shishgediin Gol; 5. Ulaan Taiga; 6. Jid; 7. Yuroo - Khuder 8. Zakhar-Minj; 9. Baga Khentii

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Table 9. Seed regions of Siberian spruce forests

№	Seed region	Vegetation period, day	Average annual air temperature, °C	Sum of the temperature above 5°C	Total annual precipitation, mm	Moisture coefficient	Average air temperature, °C [Conrad's index of continentally, %]
1	Yoltiin Gol	131	-0.34	2147.1	107.0	0.65	-21.4 (17.3). [89]
2	Uvs Nuur	155	-1.41	2848.2	109.2	0.42	-31.6 (22.4). [93]
3	Tesiin Gol	130	-0.39	2002.2	185.9	1.08	-32.4 (17.8). [88]
4	Shishgediin Gol	121	-6.67	1536.3	218.3	1.58	-34.4 (15.7). [97]
5	Ulaan Taiga	123	-5.37	1592.4	272.2	1.96	-30.1 (15.2). [87]
6	Jid	143	0.16	2119.9	309.6	1.46	-23.3 (19.4). [79]
7	Yuroo - Khuder	133	-1.01	1565.0	334.3	1.55	-26.8 (19.4). [91]
8	Zakhar Minj	146	-0.34	2050.5	292.2	1.45	-23.2 (19.1). [81]
9	Baga Khentii	132	-1.31	1929.0	312.6	1.94	-22.8 (16.8). [76]

**Source: Meteorological and Environmental Monitoring Agency*

Table 10. Siberian spruce (Picea obovata Ldb.) seed region covers the following soums in certain aimag territory

Seed region		Seed region includes the following territory of soums
№	Name	
1	Yoltiin Gol	Altai soum, Bayan-Olgii aimag;
2	Uvs Nuur	Davst soum, Uvs aimag;
3	Tesiin Gol	Tes, Bayantes soums, Zavkhan aimag;
4	Shishigtiin Gol	Tsagaannuur soum, Khovsgol aimag;
5	Ulaan Taiga	Renchinlkhümbe soum, Khovsgol aimag;
6	Jid	Tushig, Tsagaannuur soums, Selenge aimag;
7	Yuroo - Khuder	Yuroo, Khuder, Bugant soums Selenge aimag;
8	Zakhar - Minj	Mongonmorti soums, Tov aimag; Tsenkhermandal, Batshireet, Binder Delgerkhaan soums, Khentii aimag;
9	Baga Khentii	Capital (metropolis) Ulaanbaatar; Erdene, Bayandelger soums, Tov aimag;

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CONCLUSIONS

We have identified 19 seed regions for Siberian larch (*Larix sibirica* Ldb.), Dahurian larch (*Larix dahurica* Turcz.), Chekanowskii larch (*Larix Chekanowskii* Szaf.); 12 regions for Scots pine (*Pinus sylvestris* L.); 9 regions for Siberian pine (*Pinus sibirica* Du Tour.); 6 regions for Siberian fir (*Abies sibirica* Ldb.); and 9 seed regions for Siberian spruce forests (*Picea obovata* Ldb.), and have developed a map on a scale of 1:1 000 000 which will serve as a basic material for further seed management efforts with an emphasis on conservation of forest genetic resources and tree breeding in coniferous forests in Mongolia.

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REFERENCES

1. Barchenkov A. P., Milyutin L. I., Jamiyansüren S., Variability of Siberian larch (*Larix sibirica* Ledeb.) generative organs in mountain populations in Mongolia and adjacent regions of Russia, Siberian Journal of Forest Science. N. 4: 2015, pp. 58–64, (In Russian)
2. DeFries, S. M. G. et al. Pan-European strategy for genetic conservation units. Rome: European Forest Genetic Resources Programme (EUFORGEN), Biodivesity International. 2015, p. 42.
3. Dorjgotov D. Soil of Mongolia, Thesis, M.,1992, p. 51, (In Russian)
4. Dugarjav, Ch. Larch forests in Mongolia, Ulaanbaatar, 2006, p. 318, (In Mongolian)
5. Forests of the Mongolian People's Republic (Larch forest of Central Khangai). Nauka, Novosibirsk, 1983, p. 149. (in Russian)
6. Forests of the Mongolian People's Republic (Larch forest of Eastern Khentii). Nauka, Moskow, 1988, p. 177. (in Russian)
7. Forests of the Mongolian People's Republic (Geography and topology). Nauka, Moskow, 1978, p. 128. (in Russian)
8. Hamann, A., Gylander, T. and Chen P. Y. Developing seed zones and transfer guidelines with multivariate regression trees. Berlin, Heidelberg: Springer. Tree Genetics & Genomes 7: 2010, pp. 399-408.
9. Jamyansüren, S., Milyutin L. I. Variability of seed quality in the Mongolian populations *Larix sibirica* and *Pinus sylvestris*. Conservation of forest genetic resources in Siberia. Proceedings of 3rd international conference. Krasnoyarsk, pp. 45-46, (In Russian)
10. Jamyansüren, S. Difference of *Larix gemlinii* Rupr, *Larix sibirica* Ldb- Eastern Khentii. Journal of Agriculture. UB., 1985, pp. 22-24
11. Jamyansüren, S. Some issues on seed management of Siberian larch. Proceeding of the conference of forest restoration and reforestation in Republic of Mongolia. Ulaanbaatar, pp. 16-19. (In Mongolian)
12. Milyutin L. I., Jamyansüren, S. Barchenkov A. P. Variability of Siberian larch (*Larix sibirica* Ledeb.) Khangai in Mongolia / Lesovedenie (Russian journal of forest science). 2: 2015, pp.24-27, (In Russian)
13. Milyutin L. I., Suntsov A.V., Jamyansüren, S. Genetics selection features of the main

Vol. 59 No 02 (230) 2019
DOI: https://doi.org/10.5564/pmas.v59i2.1216
https://www.mongoliajol.info/index.php/PMAS

forest species of the Eastern Khentei. Nauka, Moskow, 1988, pp. 75-118. (in Russian)
14. Natsagdorj, L. Assessment of forest seed quality and weather conditions. Siberian larch and pine seed quality analysis conducted by Forest Seed Laboratory.UB. 2012, pp. 79-97, (In Mongolian)
15. Parker, W. H. and van Niejenhuis, A. Regression-based focal point seed zones for Picea mariana from northwestern Ontario. Canadian Journal of Botany 74 (8): 1996, pp. 1227-1235.
16. Paul, M. et al. Concept for the Conservation and Sustainable Utlization of Forest Genetic Resources in the Federal Republic of Germany. Bonn: Federal Ministry of Food, Agriculture and Consumer Protection. 2010, p. 76.
17. Udval, B. Growth characteristics, seed crop and seed quality of seed stands of Scotch pine (*Pinus sylvestris* L.). Dissertation. Ulaanbaatar. 2014, p. 98. (In Mongolian)