1   **Growth characteristics of natural and planted Dahurian larch in northeast China**

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12   **Abstract**. Dahurian larch (*Larix gmelinii* Rupr.) is the dominant species in both natural and

13   planted forests in northeast China, which situated in the southernmost part of the global

14   boreal forest biome and undergoing the greatest climatically induced changes. Published

15   studies (1965–2015) on tree aboveground growth of *Larix gmelinii* forests in northeast China

16   were collected in this study, critically reviewed, and a comprehensive growth data set was

17   developed from 123 sites, which distributed between 40.85 ° N and 53.47 ° N in latitude,

18   between 118.20 ° E and 133.70 ° E in longitude, between 130 m and 1260 m in altitude. The

19   data set was composed of 776 entries, including growth data (mean tree height, mean DBH,

20   mean tree volume and/or stand volume) and the associated information, i.e., geographical

21   location (latitude, longitude, altitude, aspect and slope), climate (mean annual temperature

22   (MAT) and mean annual precipitation (MAP)), stand description (origin, stand age, stand

23   density and canopy density), and sample regime (observing year, plot area and number). It

would provide quantitative references for plantation management practices and boreal forest growth prediction under future climate change. The data set is freely available for noncommercial scientific applications, and the DOI for the data is https://doi.org/10.1594/PANGAEA.880984.

1 Introduction

Boreal forests, the second largest biome in the world, cover about one-third of the Earth's forest area (Keenan et al., 2015). Dahurian larch (*Larix gmelinii* Rupr.) is a dominant tree species in Chinese boreal forest, which is distributed primarily in northeast China. *Larix gmelinii* forest is also the predominant timber source in China, occupying 55% of Chinese boreal forest area and accounting for 75% of Chinese boreal forest volume (Xu, 1998; Zhou et al., 2002). *Larix gmelinii* forest is situated in the southernmost part of the global boreal forest biome (Shugart et al., 1992) and undergoing the greatest climatically induced changes. Thus understanding the growth characteristics of *Larix gmelinii* forest in China are of critical need for management and prediction under future climate change.

With increased greenhouse effective and climate warming in recent years, forest carbon sink is payed more and more attention by the world. Forestation is the main measure to offset the greenhouse gas emission and increase carbon sink. China has the largest area of forest plantations in the world, approximately 79 million ha or one-fourth of world total (FAO, 2015; Payn et al., 2015). *Larix gmelinii* is an important fast-growing and cold-tolerant tree species used in forestation in northeast China. *Larix gmelinii* is usually planted after fire or logging. The growth rates of *Larix gmelinii* plantations are important indexes in the assessment of forest recovery processes and carbon sequestration potentials, which could supply strategies for post-fire or post-harvest management. The data set can provide basis for evaluating and predicting the carbon sequestration and its potential of the forestation

activities.

Relating the easily measured variables (e.g. tree height, diameter) to other structural and functional characteristics, is the most common and reliable method for estimating forest biomass, net primary production and biogeochemical budgets (Luo, 1996; Fang et al., 2001). For larch forests in northeast China, synthesis studies mainly focused on biomass and net primary production with a small quantity of samples, for example, N=28 (Luo, 1996), N=17 (Wang et al., 2001a), N=18 (Wang et al., 2001b; Zhou et al., 2002), N=36 (Wang et al., 2005), N=83 (Wang et al., 2008). However, large numbers of growth measurements (e.g. tree height, DBH, volume) have scarcely been studied systematically at the large scale. Therefore, a comprehensive growth data set (N=776) of Dahurian larch in northeast China was developed in this paper.

2 Data and methods

2.1 Research origin descriptors

(1) Identity: Growth data set of natural and planted Dahurian larch in northeast China, version 1.0

(2) Originators:

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Guangsheng Zhou, Chinese Academy of Meteorological Sciences, Beijing 100081, China.

(3) Period of Study: From January 1965 to December 2015

(4) Objectives: We conducted a complete literature and book review of published studies on tree height, DBH, and/or volume in *Larix gmelinii* forests including natural and planted forests in order to develop a growth data set. The data set can be used to analyze growth

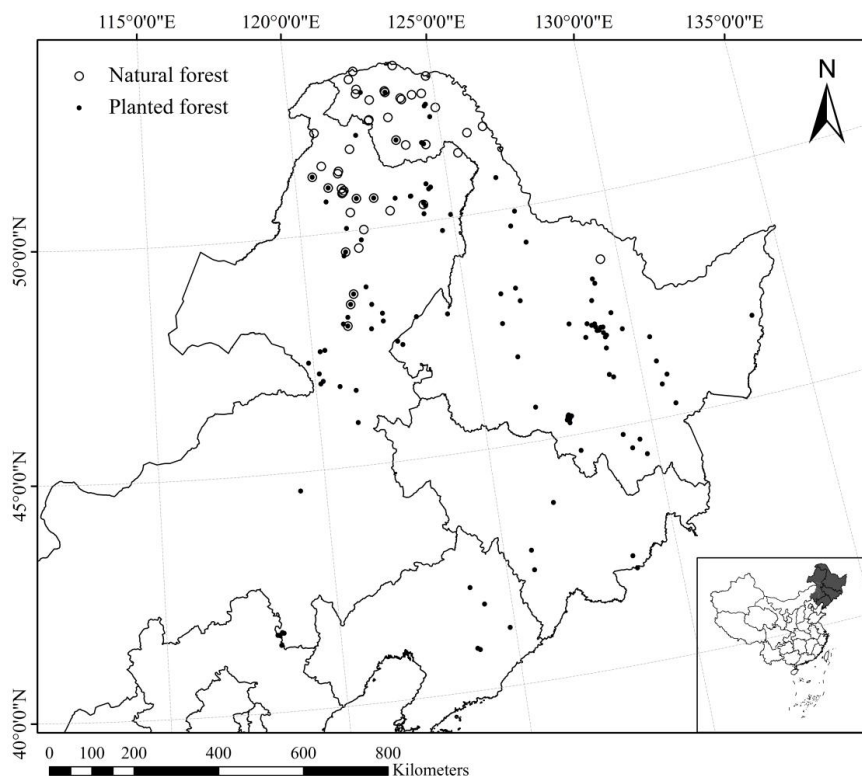
73 characteristics of *Larix gmelinii* forests and assess their potential productivity in future

74 climate warming.

2.2 Site description

76 **(1) Site type:** Data were derived from 123 study sites in northeastern China. This region

77 includes Heilongjiang, Liaoning, Jilin provinces and the eastern part of Inner Mongolia

78 Autonomous Region (Fig. 1).

79

80 Figure 1. Study sites of *Larix gmelinii* across northeastern China, including Heilongjiang,

81 Liaoning, Jilin provinces and the eastern part of Inner Mongolia Autonomous Region. Open

82 circles represent natural forests and dots represent planted forests.

83 **(2) Habitat:** *Larix gmelinii* forest is naturally distributed in Great Xing'an Mountains of

84 northeastern China. *Larix gmelinii* was usually planted in barren hills, post-fire or

85 post-harvest area in northeast China.

86 **(3) Climate:** The climate in northeast China is controlled by the high latitude East Asia

87 monsoon, changing from cool temperate to temperate zones from north to south, and from

88 semi-arid to humid zones from west to east. Mean annual temperature (MAT) for these sites

89 ranged from -6.1 to 7.0 ℃, and mean annual precipitation (MAP) from 355 to 926 mm.

90 ## 2.3   Data sources

91 Published studies (1965-2015) were collected from available online full-text databases,

92 including China Knowledge Resource Integrated Database (http://www.cnki.net/), China

93 Science and Technology Journal Database (http://www.cqvip.com/), Wanfang Data

94 Knowledge Service Platform (http://www.wanfangdata.com/), ScienceDirect (http://www.

95 sciencedirect.com/), ISI Web of Science (http://isiknowledge.com/) and Springer Link

96 (http://link.springer.com/). The different combination of the terms "Dahurian larch (or *Larix*

97 *gmelinii*)" with "height", "diameter at breast height (or DBH)", "tree volume" and "stand

98 volume" were searched in full text. Meanwhile, we also looked up the related books (e.g. Ma,

99 1992; Wang, 1992; Zhou, 1994; Yang, 2009). We attempted to compile a complete growth

100 data set of natural and planted Dahurian larch in northeastern part of China (between 40.85 °

101 N and 53.47 °N; between 118.20 °E and 133.70 °E).

102 ## 2.4   Data collection criteria

103 A critical review of the literatures collected from the above-mentioned sources was

104 conducted to obtain reliable growth data using the following criteria:

105 **(1) Scope:** The objective of this study was to provide the data for understanding growth

106 characteristics of *Larix gmelinii* natural forests (pure *Larix gmelinii* or its proportion more

107 than 50%) and monoculture plantations. Forest stands included in the data set were restricted

108 to those not recently disturbed by logging, fire, or insect pests. Additionally, the following

109 small numbers of special types were excluded: (i) *Larix gmelinii* afforestation in wetland (Li

110 et al., 1985; Song & Li, 1990; Huang, 2011; Cui et al., 2013), pastureland (Duan, 2005), or

111 abandoned mine land (Yang et al., 2013); (ii) hybrid test between *Larix gmelinii* and other

112 larch (Deng et al., 2010; Zhang et al., 2005); (iii) low-yield stands in hard environment, e.g.

113 igneous rock forest (Wang et al., 1979), old man forest (Wang et al., 1991).

114 **(2) Study design and sampling:** Tree height and DBH were averaged from the measurement

115 values of all trees in plots or with random/systematic sampling method. Tree regeneration

116 layer, generally below 5 cm in DBH or 1.3 m in height, was neglected in sampled plots. Stem

117 volume of individual tree was computed from felled-wood samples or local tree volume

118 equations. Stand volume was usually calculated by multiplying mean individual volume with

119 stand density. Besides the growth data (i.e. height, DBH and/or volume), the necessary

120 information should be provided in the original sources, e.g., study site, stand orign, stand age,

121 etc.

122 **(3) Quality control:** The data quality has been carefully reviewed by the authors. Data has

123 undergone substantial checking, for example, cross-check for the relevant information from

124 different sources, preliminary correlation analysis among growth variables.

125 Consequently, 776 records that met the above criteria were selected to develop a

126 comprehensive growth data set of Dahurian larch in China. The data set includes growth

127 characteristics of Dahurian larch (i.e. mean tree height (m), mean DBH (cm), mean tree

128 volume (10^{-3} m^3) and/or stand volume (m^3/ha)). In addition, associate information was

129 included, if available in original sources or ascertainable from other relevant literatures, i.e.,

130 geographical location (province location and locality name of study site, latitude (°),

131 longitude (°), altitude (m), aspect and slope (°)), stand description (origin, stand age (years),

132 stand density (trees/ha) and canopy density), climate (mean annual temperature (MAT, ℃)

133 and mean annual precipitation (MAP, mm)), and sample regime (observing year, plot size and

134 number).

135 **2.5 Data structural descriptors**

136 Table 1 Variable information in the data set.

Column code	Definition	Unit	Number	Range
ID	Unique identification number of each record	N/A	776	1—776
Province	Province location of study site	N/A	776	N/A
Study site	Locality name of study site	N/A	123	N/A
Latitude	Latitude of study site	°	776	40.85—53.47
Longitude	Longitude of study site	°	776	118.20—133.70
Altitude	Altitude of study site	m	776	130—1260
Aspect	Slope direction of study site, including flat slope (FL), sunny slope (SU: South), half-sunny slope (HSU: West, Southwest, Southeast), shady slope (SH: North) and half-shady slope (HSH: East, Northwest, Northeast)	N/A	300	N/A
Slope	Slope degree of study site	°	357	0—60
Origin	Stand origin was classified into natural and planted forests	N/A	776	N/A
MAT	Mean annual temperature, from original study or other related ference	℃	776	-6.1—7.0
MAP	Mean annual precipitation, from original study or other related reference	mm	776	355—926
Age	Stand age, which is generally defined as age since germination in natural forest and since planting in planted forest. Stand age is usually obtained from historical records or tree rings.	years	776	1—280
Height	Mean tree height	m	670	0.24—29.40
DBH	Mean diameter at breast height, base diameter was only given in some young forests and marked with [B]	cm	661	0.70—34.89
V_{tree}	Mean tree volume, the estimated tree volume data from the two-variable larch equation were marked with [E]	$10^{-3}\,m^3$/tree	696	0.04—935.73
V_{stand}	Stand volume, the estimated stand volume data from the estimated tree volume and stand density were marked with [E]	m^3/ha	590	0.07—975.32
Density	Stand density/Canopy density, planting density was only given in some studies and marked with [P]	trees/ha %	656 150	213—13275 0.2—1.0
Area	Plot area	m^2	397	50—10000
Plot	Plot numbers, i.e. replications	N/A	573	1—25
Year	Investigation year	N/A	533	1954—2014
Reference	Data sources, the sources used to supplement climate information lacking in the original publications were added asterisks.	N/A	226	1965—2015

137

3 Data estimates and evaluation

3.1 Geographical location

140 Google Earth (Version: 7.1.8.3036) was used to estimate latitude, longitude, and/or altitude

141 when the geographic coordinates was unavailable in original sources.

3.2 Tree and stand volume

143 The missing tree and stand volumes were estimated with the available information (mean

144 DBH, mean tree height and stand density). Stem volume of individual tree was calculated

145   with the larch equation in northeast China (V_{tree}= 0.000050168241 DBH$^{1.7582894}$ H$^{1.1496653}$),

146   the best method recommended by the national standard of China: Tree volume tables (LY

147   208-77) (Forestry Administration of China, 1978; Liu, 2017). Meanwhile, available 590 pairs

148   of mean tree height and mean DBH in the data set were used to establish the linear H-DBH

149   correlation (R^2=0.8377, see Fig. 2). To calculate tree volume from only one known variable

150   of DBH, tree height was firstly calculated with the linear H-DBH equation in Fig. 2. The

151   estimated stand volume was determined by multiplying the estimated tree volume with stand

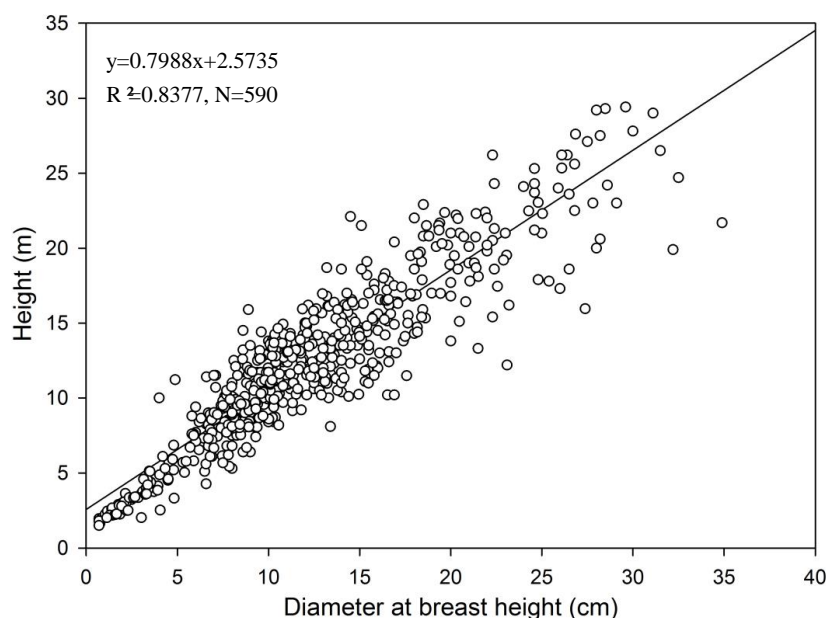
152   density.

153   The accuracy of tree volume was assessed by comparing the extracted data from references

154   with the calculated data from the above-mentioned two-variable tree volume equation (Fig. 3).

155   The coefficient of determination (R^2) was 0.9724 and the slope was 1.0737. Therefore, we

156   were confident in applying the larch volume equation to interpolate tree and stand volume

157   data in this study.

158

159   Figure 2. Relationship between mean tree height and diameter at breast height in the data set.

160

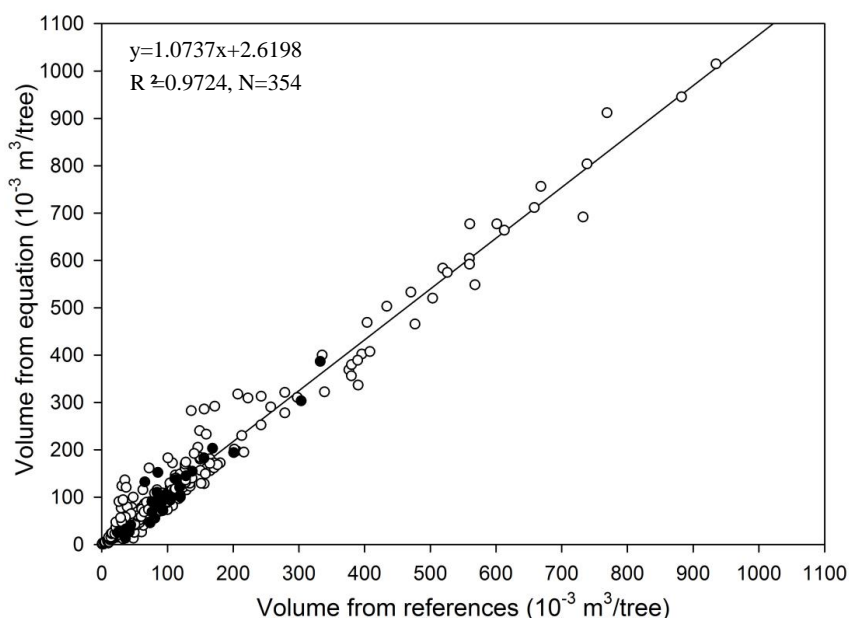



Figure 3. Comparison of available tree volume from references with simulated values from the two-variable tree volume equation ($V_{tree}=0.000050168241$ $DBH^{1.7582894}$ $H^{1.1496653}$). Open circles (N=317): tree height (H) and diameter at breast height (DBH) were available in the references, solid circles (N=37): DBH was only available in the references and H was estimated with the H-DBH correlation from Fig. 2.

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Acknowledgements. We would like to acknowledge the many scientists and researchers whose field measurements made this work possible. This research was supported by the National Key Research and Development Program of China (2017YFC0503906) and China Special Fund for Meteorological Research in the Public Interest (GYHY201406034).

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