3044

A Chronosequence of Wood Decomposition in the Boreal Forests of Russia

(MS Thesis by Mikhail Yatskov; June 2001)

This web page is a part of MS thesis «A Chronc Forests of Russia» by Mikhail Yatskov, a gradu was funded by the National Science Foundation

Until recently there was virtually no experience Our project was aimed at improving understand throughout Russia. We measured the stores and provided a basis for assessment of the carbon pc major forest region of the globe -- the Russian t:

The project is a part of larger scientific effort as by woody detritus in the forests of Russia. The : Russian boreal forest (Map of Russia). Data col 1996 to 1999. Data collection for decay-specific while sampling for the decomposition rate calcu Krasnoyarsk, Irkutsk, and Khabarovsk regions.

The major outputs of this project include the vo used to convert dead wood volume data into car detritus decomposition rates of major tree species in four geographic regions of Russia were determined. These rates have expose debris in Russian boreal forests.

- **Project coordinators and participants**
- **Description of the chronosequence approach**
- **Project results**
  - Decay-class specific density
  - Multivariate analysis of CWD visual characteristics
  - Decomposition rate-constants
- **Decay class description and photos**
  - Birch (*Betula pendula* and *Betula costata*)
  - Kedr (*Pinus koraiensis* and *Pinus sibirica*)
  - Larch (*Larix daurica* and *Larix sibirica*)
  - Pine (*Pinus silvestris*)
  - Spruce (*Picea abies*, *Picea obovata*, and *Picea ajanensis*)
- **List of publication from this and related studies**

Questions? Email Dr. Mark Harmon at mark.harmon@orst.edu or Dr. Olga Krankina at olga.krankina@orst.edu

Return to the top of this page.

Project coordinators and participants

Mark E. Harmon
Richardson Professor, Forest Ecology; Department of Forest Science, Oregon State University
EMAIL: Mark.Harmon@orst.edu PHONE: (541) 737-8455
FAX: (541) 737-1393

MAILING ADDRESS:
Mark E. Harmon
321 Richardson Hall
Forest Science
Oregon State University
Corvallis, OR 97331-5752

HOME PAGE at http://www.cof.orst.edu/cof/fs/instruct/grad_fac/harmonm.htm

---

Olga N. Krankina
Faculty Research Associate; Department of Forest Science, Oregon State University
EMAIL: Olga.Krankina@orst.edu PHONE: (541) 737-1780
FAX: (541) 737-1393

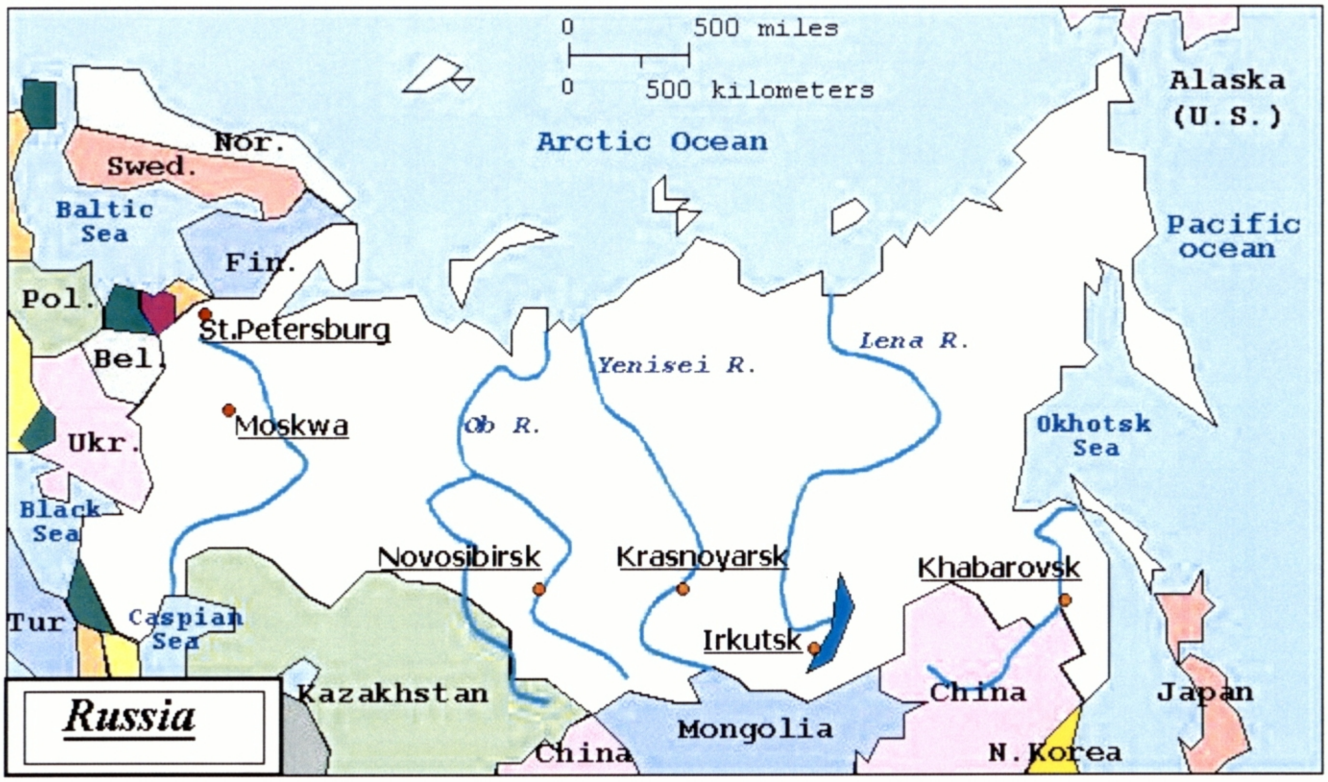
MAILING ADDRESS:
Olga N. Krankina
321 Richardson Hall
Forest Science
Oregon State University
Corvallis, OR 97331-5752

Mikhail A. Yatskov
Graduate Research Assistant, Forest Ecology; Department of Forest Science, Oregon State University
EMAIL: Mikhail.Yatskov@orst.edu PHONE: (541) 758-6325
FAX: (541) 737-1393

MAILING ADDRESS:
Mikhail A. Yatskov
321 Richardson Hall
Forest Science
Oregon State University
Corvallis, OR 97331-5752

Map of Russia showing locations of Regional Forest Inventory Head Offices representing areas where data and samples were collected.

Russia (Map)



Participants in Russia:

- **West-Siberian State Forest Management Enterprise**
  Kresnov, Vladimir Gennadievich
  630048, Novosibirsk
  Nemirovicha-Danchenko str., 137/1
  Phone: 7 (383) 2 54-55-77
  EMAIL: lesgis@online.sinor.ru

- **Central State Forest Management Enterprise**
  Kashpor, Nikolai Nikolaevich
  117418, Moskwa
  Novocheremushkinskaya str., 69
  Phone: 7 (095) 332-51-67

- **East-Siberian State Forest Management Enterprise**
  Skudin, Viktor Mikhailovich
  660062, Krasnoyarsk
  Krupskoi str., 42
  Phone/Fax: 7 (391) 2 45-28-30
  Phone: 7 (391) 2 45-32-24

Far-Eastern State Forest Management Enterprise
Protasov, Nikolai Aleksandrovich
680006, Khabarovsk
Volochaevskaya str., 4
Phone: 7 (4212) 36-18-94

From left to right: Kresnov V.G., Kashpor N.N., Skudin V.M., Reshetnikov A.A., Protasov N.A..

Baikal Region State Forest Management Enterprise
Reshetnikov, Albert Aleksandrovich
664040, Irkutsk
Rozy Lyuksemburg str., 150
Phone: 7 (3952) 45-04-19

Questions? Email Dr. Mark Harmon at mark.harmon@orst.edu or Dr. Olga Krankina at olga.krankina@orst.edu

Back to the Main Page.

Return to the top of this page.

A Chronosequence approach of the study

The study has measured woody detritus decomposition rates using a chronosequence approach. The chronosequence approach is a specific technique of dating pieces of wood that have decomposed various times. There are two major challenges in this approach. The first one has to do with attempts to date or age the pieces of coarse woody debris in various states of decay. In Russia for this purpose we have used:

- extensive forest inventory records of the events causing single-tree mortality or death of the entire stands such as wild fires, wind throws, wind breaks, bark beetle kill, and gypsy moth kill;
- records of anthropogenic activities such as road construction and various types of harvest;
- in-field log and snag dating by the age of replacement stands, the age of a tree growing on a log, the age of a fire scar on living tree, the age of a scar left by a fallen tree, and the age of a scars left in permanent forest inventory plots on marked trees;
- trees cut in the past by forest inventory crew for constructing growth and yield tables for various species during permanent plot inventory.

The second challenge has to do with attempts to determine the species of the coarse woody debris. For late decay classes we have used such characteristics for species identification as long-lasting branch stubs in spruce logs, long-lasting bark in pine and larch, specific smell of Korean and Siberian white pine logs that can be detected in branch stubs found in completely deteriorated logs, and the long-lasting bark in white birch logs that stays in the soil even after the entire heartwood and sapwood is gone.

These scars were made recently by the inventory crew to mark trees in permanent plots. Healing wounds can be used in the future to determine the age of snags forming from the marked trees.

Korean pine logs pushed by bulldozer to clean the space for the road construction in 1965.

Spring 1997 forest fire recorded in the forest inventory gives a precise date of forest stand mortality.

Forest inventory data indicated this stand to be damaged by windthrow in 1997.

The scar on the young live tree to the left can reveal when the nearby tree fell and became a log.

Long-lasting branch stubs can be used for identification of spruce logs in the late decay stage.

An inventory crew member cut these pine trees in 1972 for taking measurements used in construction of the growth and yield tables.

The age of the catastrophic wild fire can be approximated from the age of the 65-year old birch trees that established after the fire.

Questions? Email Dr. Mark Harmon at mark.harmon@orst.edu or Dr. Olga Krankina at olga.krankina@orst.edu

Back to the Main Page.

Return to the top of this page.

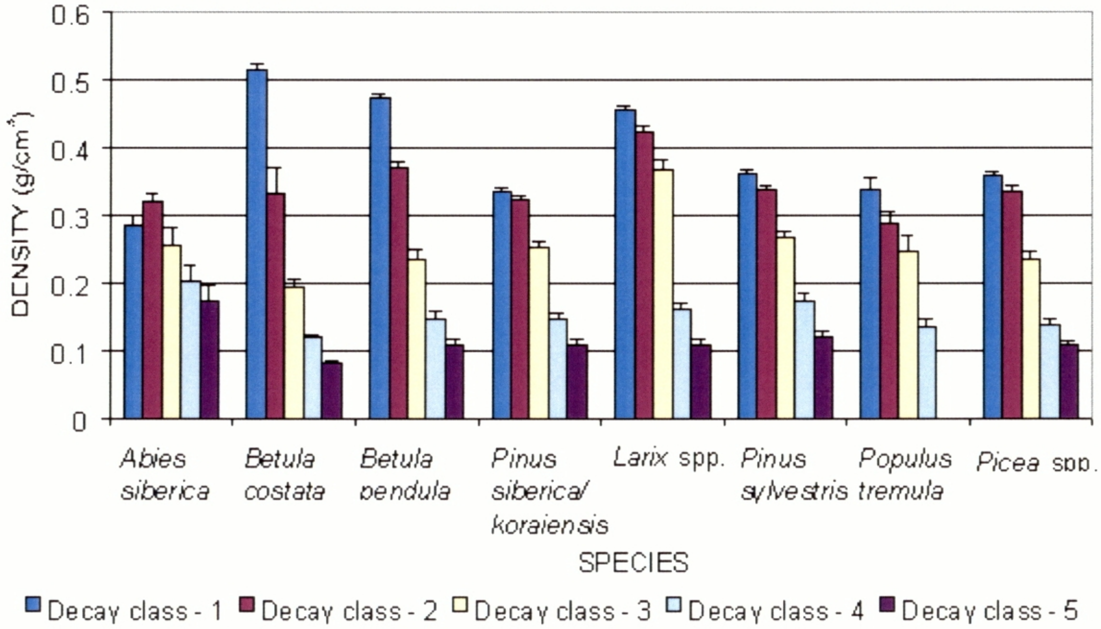
Decay-class specific density

Mean densities (g/cm3) and SE's (in parenthesis) of CWD by decay class and species for major tree species of Russia

	Species					
Decay classes	*Abies siberica*	*Betula costata*	*Betula pendula*	*Larix spp.*	*Pinus sylvestris*	*Pinus siberica/ koraiensis*
1	0.285 (0.016)	0.516 (0.007)	0.474 (0.005)	0.455 (0.007)	0.362 (0.005)	0.336 (0.006)
2	0.320 (0.012)	0.333 (0.037)	0.370 (0.009)	0.424 (0.009)	0.338 (0.006)	0.322 (0.006)
3	0.257 (0.024)	0.194 (0.012)	0.237 (0.014)	0.368 (0.013)	0.269 (0.009)	0.252 (0.011)
4	0.204 (0.021)	0.120 (0.005)	0.148 (0.012)	0.162 (0.008)	0.172 (0.012)	0.146 (0.008)
5	0.173 (0.025)	0.084 (0.003)	0.108 (0.010)	0.109 (0.008)	0.122 (0.006)	0.109 (0.007)

A gradual decrease in mean density from decay class one to decay class five was observed in all species except *Abies siberica*. In addition, species became more similar in density as decay class increased.

Estimates of mean specific density with error bars plotted against species by decay class



Back to the project HOME page.

Questions? Email Dr. Mark Harmon at mark.harmon@orst.edu or Dr. Olga Krankina at olga.krankina@orst.edu

Multivariate analysis of CWD visual characteristics

Multivariate analysis was used to analyze the changes in CWD visual characteristics occurring as a result of the decomposition process. Non-metric Multidimensional Scaling (NMS) analysis with rotation of the axes was performed. The axes rotation to one degree resulted in the first axis having the higher coefficient of determination (r^2) of the two.

Variables in the approximate sequence of their appearance and correlation coefficients between them and scores on the ordination axes

Variables	Axis 1	Variables	Axis 2
BARKBOLE	-0.746	BARKBR	-0.312
BARKBR	-0.733	TWIGS	-0.299
BRANCHES	-0.716	NEEDLES	-0.261
TWIGS	-0.700	BRANCHES	-0.215
BCOVER	-0.648	SCATTER	-0.177
NEEDLES	-0.459	BCOVER	-0.172
BEETLES	-0.393	COLLAPSE	-0.138
WOODBORER	-0.129	HWFRIAB	-0.082
CONKS	-0.109	STUBSMOV	-0.065
LICHENS	0.073	BROWNROT	-0.028
ANTS	0.115	BARKBOLE	-0.018
CASEHARD	0.211	CASEHARD	-0.01
WHITEROT	0.464	MOSS	0.073
STUBSMOV	0.623	LICHENS	0.078
SCATTER	0.647	SAPFRIAB	0.118
MOSS	0.659	ANTS	0.127
BROWNROT	0.697	CONKS	0.159
COLLAPSE	0.718	SAPSLOUG	0.159
HWFRIAB	0.743	WHITEROT	0.261
SAPSLOUG	0.763	BEETLES	0.346
SAPFRIAB	0.858	WOODBORER	0.381

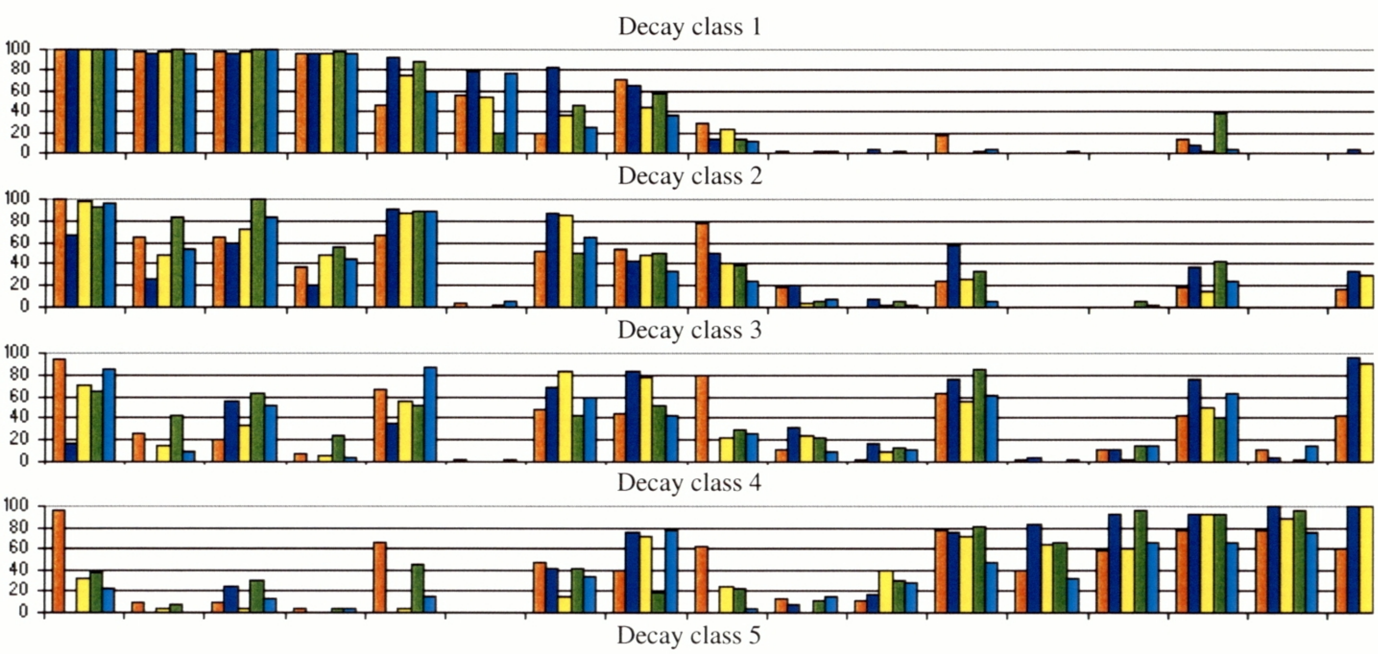
Variables associated with early stages of decomposition (bark on bole, bark on branches, branches, and twigs) had lower scores, whereas variables associated with late stages of decomposition (heartwood friable, sapwood sloughing, and sapwood friable) had higher axis scores.

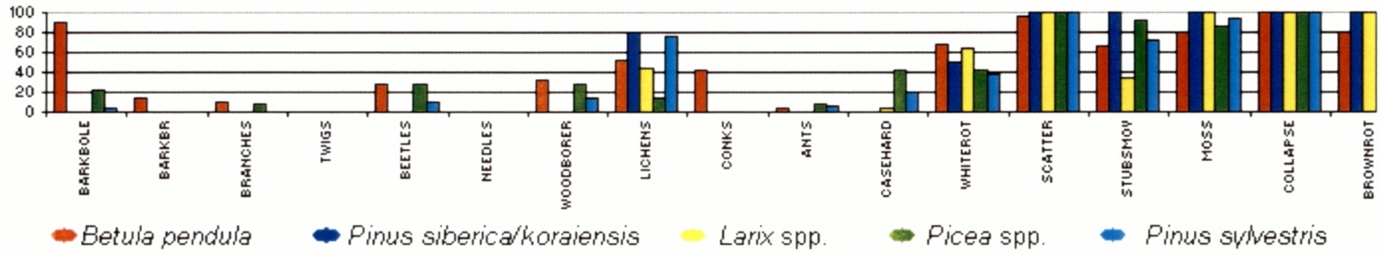
Correlations of indicator variables in ascending order to scores on the ordination axis one for five taxa well represented in the study area

Betula pendula		*Pinus siberica/koraiensis*		*Larix spp.*		*Picea spp.*	
Variables	r	Variables	r	Variables	r	Variables	r
BRANCHES	-0.817	BARKBOLE	-0.854	BARKBOLE	-0.814	BARKBOLE	-0.724
BARKBR	-0.799	BARKBR	-0.795	BCOVER	-0.801	BARKBR	-0.702
TWIGS	-0.707	BCOVER	-0.788	BRANCHES	-0.769	BRANCHES	-0.663
NEEDLES	-0.435	TWIGS	-0.787	BARKBR	-0.710	BCOVER	-0.635
BCOVER	-0.257	BEETLES	-0.739	TWIGS	-0.704	TWIGS	-0.567
LICHENS	-0.226	NEEDLES	-0.650	BEETLES	-0.660	BEETLES	-0.496
BARKBOLE	-0.200	BRANCHES	-0.586	NEEDLES	-0.429	NEEDLES	-0.395
BEETLES	0.008	WOODBORER	-0.444	WOODBORER	-0.331	LICHENS	-0.151
ANTS	0.023	CONKS	-0.356	CONKS	-0.214	WOODBORER	-0.113
WOODBORER	0.038	CASEHARD	0.102	ANTS	0.094	CONKS	-0.100
CONKS	0.075	ANTS	0.166	LICHENS	0.175	ANTS	0.102
CASEHARD	0.215	LICHENS	0.259	CASEHARD	0.311	CASEHARD	0.254
WHITEROT	0.479	WHITEROT	0.563	STUBSMOV	0.543	WHITEROT	0.441
BROWNROT	0.496	SCATTER	0.652	WHITEROT	0.544	MOSS	0.477
MOSS	0.549	COLLAPSE	0.667	SCATTER	0.730	BROWNROT	0.546
STUBSMOV	0.665	STUBSMOV	0.668	MOSS	0.746	SCATTER	0.567
SAPSLOUG	0.669	MOSS	0.703	COLLAPSE	0.766	COLLAPSE	0.617
SCATTER	0.683	HWFRIAB	0.767	HWFRIAB	0.787	SAPFRIAB	0.638
COLLAPSE	0.787	BROWNROT	0.810	BROWNROT	0.834	SAPSLOUG	0.657
HWFRIAB	0.793	SAPSLOUG	0.859	SAPFRIAB	0.862	STUBSMOV	0.680
SAPFRIAB	0.846	SAPFRIABPFRIAB	0.870	SAPSLOUG	0.874	HWFRIAB	0.686

There were no significant differences among five best-represented species in terms of the variables correlated to the scores on ordination axis one. However, correlation coefficients of birch bark cover (-0.257) and bark on bole (-0.200) were low, and indicate little change in birch bark presence on bole and percent bark cover over the course of decomposition. This contrasts the coniferous species, which have a high correlation of these variables to first ordination axis, with correlation coefficients ranging from -0.635 to -0.801 and from -0.724 to -0.854 for bark cover and bark on bole, respectively. These indicate a decrease in percent bark cover and bark presence on bole for conifers occurring over the course of decomposition.

Frequency of an indicator (in percent) occurring in CWD of different decay classes by species





A plot of percent frequency of indicator occurrence suggests that the presence of bark on boles may be the single most important indicator separating birch from all coniferous species. Due to the extended bark presence in birch the presence of characteristics such as beetles, wood borers, conks and their traces (galleries, holes) can be detected in birch in more advanced decay classes than in conifers. The latter loose their bark early in decomposition, so it is almost impossible to detect the presence of these biotic indicators in coniferous logs of decay classes four and five. Also, the difference between birch and conifers was indicated by early occurrence (decay class one) of white rot in birch logs and snags, while in conifers the appearance of this type of rot was recorded for decay classes two, three, four and five.

Another difference among the species was the high percent of occurrence of friable sapwood and sapwood sloughing in decay class two CWD of Korean and Siberian pines and low percent of bark on bole occurrence in decay class three of the same species. For example, by decay class two about 60 percent of the white pine CWD pieces sampled had friable sapwood or sapwood sloughing as opposed to less than 20 percent in the other species; and less than 20 percent of the white pine boles had bark present by decay class three, while the bark presence was observed on 65 to 95 percent of other species' boles. This pattern in white pines may be explained by the slow decomposition of heartwood of these species.

Back to the project HOME page.

Questions? Email Dr. Mark Harmon at mark.harmon@orst.edu or Dr. Olga Krankina at olga.krankina@orst.edu

Return to the top of this page.

Decomposition rate-constants

Coefficients and SE's (in parenthesis) of the regressions of percent mass remaining over decomposition time used to estimate decomposition rate constants for species studied in four regions of Russia from west to east

		Regression coefficients [a]					
		Snags					
Species	Regions	Y_0(%)	k ($year^{-1}$)	p-value*	N	Adj. r^2	Y_0 (%)
Betula pendula	St.-Petersburg	92.68	-0.027 (0.008)	0.0185	7	0.64	100.00
	Krasnoyarsk	106.53	-0.056 (0.009)	0.0001	13	0.78	107.08
	Irkutsk	108.11	-0.052 (0.009)	0.0001	17	0.67	86.56
	Khabarovsk	130.92	-0.077 (0.022)	0.0185	7	0.64	118.73
Betula costata	Khabarovsk	108.63	-0.071 (0.003)	0.0001	7	0.99	79.13
Picea abies	St.-Petersburg	118.35	-0.044 (0.018)	0.0710	6	0.50	82.48
P. obovata	Krasnoyarsk	98.53	+0.0006 (0.0043)	0.8957	8	-0.16	110.58
P. ajanensis	Khabarovsk	125.24	-0.035 (0.003)	0.0001	14	0.92	96.59
Pinus sylvestris	St.-Petersburg	103.85	-0.037 (0.009)	0.0012	14	0.56	81.76
	Krasnoyarsk	97.13	+0.020 (0.011)	0.1121	8	0.26	120.60
	Irkutsk	103.25	-0.004 (0.003)	0.2383	19	0.03	111.20
Larix siberica	Krasnoyarsk	101.45	-0.004 (0.005)	0.4168	8	-0.04	90.23
	Irkutsk	102.49	-0.010 (0.001)	0.0001	28	0.64	99.72
Larix dahurica	Khabarovsk	93.56	-0.009 (0.012)	0.4801	10	-0.05	80.70
Pinus siberica	Irkutsk	88.02	-0.003 (0.001)	0.0092	17	0.33	88.55
P. koraiensis	Khabarovsk	86.66	-0.003 (0.002)	0.3030	12	0.02	86.79

[a] The regression was of the form $Y_t = Y_0 * e^{-kt}$ where Y_t is the percentage of the mass remaining at time t (years), Y_0 is the initial mass in percent dry weight, and k is the decomposition rate constant

* P-value for the comparison of decomposition-rate constants to zero

The decomposition rate-constants ranged from -0.015 to -0.078 for logs and from -0.077 to +0.020 for snags. Some differences and some similarities were observed among decomposition rates within each species among the regions as well as within each region among the species. The differences between decomposition rates of logs and snags were fairly high for some species. In general, decomposition rates of logs were higher than those of snags. The most similar rates were in the white pine group. The log decomposition rate of Pinus siberica was not different from the log decomposition rate of Pinus koraiensis (p-value of 0.1355), as snag decomposition rate of Pinus siberica was not different from snag decomposition rate of Pinus koraiensis (p-value of 0.837).

The decomposition rates of logs were in general higher than those of snags for larch and white pine, whereas for birch the decomposition rates of logs and snags were similar. Comparison between decomposition rates of logs and snags of Picea ajanensis in Khabarovsk region, and Pinus siberica and Larix siberica in Irkutsk region indicates that while decomposition rates of logs and snags are not significantly different for Picea ajanensis (p-value of comparison 0.121), they are different for Pinus siberica and Larix siberica (p-values of 0.002 and 0.001, respectively).

Decomposition time range of sampled logs and snags in different regions

Species	Regions	Snags	Logs
Betula pendula	St.-Petersburg	0 - 12	0 - 30
	Krasnoyarsk	0 - 15	0 - 29
	Irkutsk	1 - 8	1 - 33
	Khabarovsk	2 - 15	0 - 27
Betula costata	Khabarovsk	1 - 13	2 - 77
Picea abies	St.-Petersburg	2 - 7	2 - 73
P. obovata	Krasnoyarsk	2 - 15	0 - 33
P. ajanensis	Khabarovsk	1 - 71	2 - 77
Pinus sylvestris	St.-Petersburg	1 - 13	0 - 70
	Krasnoyarsk	0 - 4	0 - 45
	Irkutsk	1 - 19	1 - 42
Larix siberica	Krasnoyarsk	0 - 15	0 - 110
	Irkutsk	1 - 65	1 - 90
Larix dahurica	Khabarovsk	8 - 19	0 - 104
Pinus siberica	Irkutsk	2 - 65	0 - 65
P. koraiensis	Khabarovsk	1 - 31	0 - 160

Time periods (years) required for a given percent of mass to decompose

Regions	Species	50% mass	95% mass	99% mass
St.-Petersburg	*Betula pendula*	13	55	85
	Pinus sylvestris	18	103	163
	Picea abies	19	108	170
Krasnoyarsk	*Betula pendula*	12	50	77
	Picea obovata	16	63	96
	Pinus sylvestris	20	72	109
	Larix siberica	26	126	196
Irkutsk	*Betula pendula*	13	68	106
	Pinus sylvestris	22	86	131
	Larix siberica	22	97	148
	Pinus siberica	30	151	236
Khabarovsk	*Betula pendula*	11	41	61
	Betula costata	15	92	146
	Picea ajanensis	24	106	163
	Larix dahurica	32	185	293
	Pinus koraiensis	37	190	298

The species ranking by their decay resistance indicate that birch is the fastest decaying species, usually followed by spruce and pine, with larch and white pine being the most decay resistant species. This pattern holds for all species and regions sampled as indicated by CWD half-life, and time required for 95 and 99% of the mass to decompose.

Back to the project HOME page.

Questions? Email Dr. Mark Harmon at mark.harmon@orst.edu or Dr. Olga Krankina at olga.krankina@orst.edu

Return to the top of this page.

Birch decay classes

Decay class one boles usually have no decay, fine twigs remaining, and complete bark coverage. The sapwood and heartwood are clear or slightly blue stained. Moss is absent.

Decay class two boles are slightly decayed with all of the bark present but no fine twigs. The sapwood and heartwood show some signs of decay.

Decay class three boles are moderately decayed with almost all of the bark present but only stubs of branches remaining. Where the bark is gone, the decomposition of wood is less apparent. The sapwood and heartwood show strong signs of decay. The bole still can support itself due to presence of outer bark, but breaks easily with the applied force.

Decay class four boles can no longer support themselves. Frequently, all the bark is still present. The sapwood and heartwood are impossible to distinguish.

Decay class five boles are detected only by their moss or grass outline on the forest floor. The cross section of the bole is no longer round but elliptical, and the most of the bark is still present. The wood resembles soil alike compound with little discernible structure or sign of rings penetrated by roots.

Decay class descriptions after Graham and Cromack, 1982.

Questions? Email Dr. Mark Harmon at mark.harmon@orst.edu or Dr. Olga Krankina at olga.krankina@orst.edu

Back to the Main Project Page.

Return to the top of this page.

Kedr decay classes

Decay class one boles usually have no decay, fine twigs remaining, and complete bark coverage. The sapwood and heartwood are clear or slightly blue stained. Moss is absent.

Decay class two boles are slightly decayed with most of the bark present but no fine twigs. The sapwood is rotted, but the heartwood is mostly sound.

Decay class three boles are moderately decayed with some bark present but only stubs of branches remaining. Where the bark is gone, some sloughing of the outer wood is apparent. The sapwood and heartwood show strong signs of decay. But the bole still can support itself.

Decay class four boles can no longer support themselves. F all the bark is gone. The sapwood is often absent, and the d red-brown heartwood crumbles into chunks upon handling. parts of heartwood and branch stubs have specific smell tha used as an identification mark for this species.

Decay class five boles are detected only by their moss or grass outline on the forest floor. The cross section of the bole is no longer round but elliptical, and the bark is completely absent. The wood resembles red powder with little discernible structure or sign of rings. Intact branch stubs have specific smell that allows to distinguish this species from the others on late stages of decay.

Decay class descriptions after Graham and Cromack, 1982.

Questions? Email Dr. Mark Harmon at mark.harmon@orst.edu or Dr. Olga Krankina at olga.krankina@orst.edu

Back to the Main Project Page.

Return to the top of this page.

Larch decay classes

Decay class one boles usually have no decay, fine twigs remaining, and complete bark coverage. The sapwood and heartwood are clear or slightly blue stained. Moss is absent.

Decay class two boles are slightly decayed with most of the bark present but no fine twigs. The sapwood is rotted, but the heartwood is mostly sound.

Decay class three boles are moderately decayed with some bark present but only stubs of branches remaining. Where the bark is gone, some sloughing of the outer wood is apparent. The sapwood and heartwood show strong signs of decay. But the bole still can support itself.

Decay class four boles can no longer support themselves. F
all the bark is gone. The sapwood is often absent, and the d
red-brown heartwood crumbles into chunks upon handling.
the bark is gone, the parts of it can still be found under the l
especially if the tree served as a log since it died. The bark
used to identify larch among the other decayed boles.

Decay class five boles are detected only by their moss or gr
on the forest floor. The cross section of the bole is no longe
but elliptical, and the bark is completely absent. The wood
red powder with little discernible structure or sign of rings.
may remain under the log through entire process of log dete
and serve as a species identification on the late stages of de

Decay class descriptions after Graham and Cromack, 1982.

Questions? Email Dr. Mark Harmon at mark.harmon@orst.edu or Dr. Olga Krankina at olga.krankina@orst.edu

Back to the Main Project Page.

Return to the top of this page.

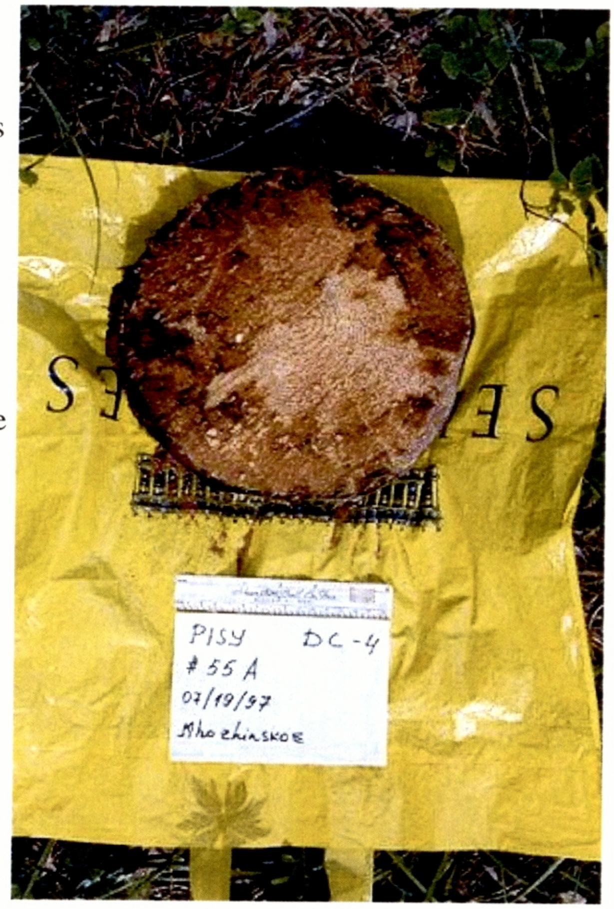
Pine decay classes

Decay class one boles usually have no decay, fine twigs remaining, and complete bark coverage. The sapwood and heartwood are clear or slightly blue stained. Moss is absent.

Decay class two boles are slightly decayed with most of the bark present but no fine twigs. Sometimes bark is absent especially if boles are damaged by fire and then, by bark beetles. The sapwood is rotted, but the heartwood is mostly sound.

Decay class three boles are moderately decayed with some bark present but only stubs of branches remaining. Where the bark is gone, some sloughing of the outer wood is apparent. The sapwood and heartwood show strong signs of decay. But the bole still can support itself.

Decay class four boles can no longer support themselves. Frequently, all the bark is gone. The sapwood is often absent, and the deep red-brown heartwood crumbles into chunks upon handling.



Decay class five boles are detected only by their moss or grass outline on the forest floor. The cross section of the bole is no longer round but elliptical, and the bark is completely absent. The wood resembles red powder with little discernible structure or sign of rings. The boles can be identified by specific pine pitch smell in the intact branch stubs. The bark sometimes remaining under the boles can also be used for pine identification.

Decay class descriptions after Graham and Cromack, 1982.

Questions? Email Dr. Mark Harmon at mark.harmon@orst.edu or Dr. Olga Krankina at olga.krankina@orst.edu

Back to the Main Project Page.

Return to the top of this page.

Spruce decay classes

Decay class one boles usually have no decay, fine twigs remaining, and complete bark coverage. The sapwood and heartwood are clear or slightly blue stained. Moss is absent.

Decay class two boles are slightly decayed with most of the bark present and most of fine twigs still remaining. The sapwood is rotted, but the heartwood is mostly sound.

Decay class three boles are moderately decayed with some bark and most of the branches present. Where the bark is gone, some sloughing of the outer wood is apparent. The sapwood and heartwood show strong signs of decay. But the bole still can support itself.

Decay class four boles can no longer support themselves. F
all the bark is gone. The sapwood is often absent, and the d
red-brown heartwood crumbles into chunks upon handling.
branches and branch stubs are present.

Decay class five boles are detected only by their moss or grass outline on the forest floor. The cross section of the bole is no longer round but elliptical, and the bark is completely absent. The wood resembles red powder with little discernible structure or sign of rings. Long lasting branch stubs can be used for spruce identification on this stage of decay.

Decay class descriptions after Graham and Cromack, 1982.

Questions? Email Dr. Mark Harmon at mark.harmon@orst.edu or Dr. Olga Krankina at olga.krankina@orst.edu

Back to the Main Project Page.

Return to the top of this page.

List of publications

Harmon, M. E., O. N. Krankina, M. Yatskov, and E. Matthews 2001. Predicting broad-scale carbon stores of woody detritus from plot-level data. In: Lai, R., J. Kimble, B. A. Stewart. Assessment Methods for Soil Carbon, CRC Press, New York, pp. 533-552.

Harmon, M. E., O. N. Krankina, and J. Sexton 2000. Decomposition vectors: a new approach to estimating woody detritus decomposition dynamics. Can. J. For. Res. 30: 76-84.

Harmon, M. E. and J. Sexton, 1996. Guidelines for measurements of woody detritus in forest ecosystems. U. S. LTER Publication No. 20.

Harmon, M. E., D. F. Whigham, J. Sexton, and I. Olmsted 1995. Decomposition and mass of woody detritus in the dry tropical forests of the Northeastern Yucatan Peninsula, Mexico. Biotropica 27: 305-316.

Harmon, M. E., Sexton, J., Caldwell, B. A., and Carpenter, S. E. 1994. Fungal sporocarp mediated losses of Ca, Fe, K, Mg, Mn, N, P, and Zn from conifer logs in the early stages of decomposition. Can. J. For. Res. 24: 1883-1893.

Harmon, M. E. and H. Chen 1991. Coarse woody debris dynamics in two old-growth ecosystems. BioScience 41(9): 604-610.

Harmon, M. E., G. A. Baker, G. Spycher, and S. E. Greene 1990. Leaf-litter decomposition in the Picea/Tsuga forests of Olympic National Park, Washington, U. S. A. For. Ecol. Manage. 31: 55-66.

Harmon, M. E., K. Cromack, Jr., and B. G. Smith 1987. Coarse woody debris in mixed-conifer forests, Sequoia National Park, California. Can. J. For. Res. 17: 1265-1272.

Harmon, M. E., J. F. Franklin, F. J. Swanson, P. Sollins, S. V. Gregory, J. D. Lattin, N. H. Anderson, S. P. Cline, N. G. Aumen, J. R. Sedell, G. W. Lienkaemper, K. Cromack Jr., and K. W. Cummins 1986. Ecology of coarse woody debris in temperate ecosystems. In: Advances in Ecological Research 15: 133-302.

Krankina, O. N., M. E. Harmon, Y. A. Kukuev, R. F. Treyfeld, N. N. Kashpor, V. G. Kresnov, V. M. Skudin, N. A. Protasov, M. Yatskov, G. Spycher, E. D. Povarov. In press. Coarse woody debris in forest regions of Russia. Can. J. For. Res.

Krankina, O. N., Harmon, M.E., Kukuev, Y.A., Treyfeld, R.F., Kashpor, N.N., Kresnov, V.G., Skudin, V.M., Protasov, N.A., Yatskov, M., Spycher, G., Povarov, E.D. 2001. Coarse woody debris in forest regions of Russia. Can. J. For. Res. (in press)

Krankina, O.N., R.F. Treyfeld, M.E. Harmon, G. Spycher, and E.D. Povarov. 2001. Coarse woody debris in the forests of St. Petersburg region, Russia. Ecol. Bull. 49: 93–104.

Krankina, O. N. and E. Kurbanov. 2000. Woody detritus in temperate pine forests of Western Russia. World Resource Review 12 (4): 741-754.

Krankina, O. N., Y. A. Kukuev, R. F. Treyfeld, M. E. Harmon, N. N. Kashpor, V. G. Kresnov, V. M. Skudin, N. A. Protasov, M. A. Yatskov, G. Spycher, and E. D. Povarov. 2000. Coarse woody debris in forest regions of Russia: Estimation methods and role of forest management for carbon sequestration. Pp. 87 In: The Role of Boreal Forests and Forestry in the Global Carbon Budget. Abstracts of an International Science Conference held May 8-12, 2000, Edmonton, Alberta.

Krankina, O. N., M. E. Harmon, and A. V. Griazkin. 1999. Nutrient stores and dynamics of woody detritus in a boreal forest: modeling potential implications at the stand level. Can. J. For. Res. 29:20-32.

Krankina, O. N. and M. E. Harmon. 1996. Nutrient stores and dynamics of woody detritus in a boreal forest: northwestern Russia. In: Sustainable Development of Boreal Forests, Proceedings of the 7th Annual Conference of the International Boreal Forest Research Association (IBFRA), August 19-23, St. Petersburg Forestry Research Institute, St. Petersburg, Russia, pp. 44-48.

Krankina, O. N. and M. E. Harmon. 1995. Dynamics of the dead wood carbon pool in northwestern Russian boreal forests. Water, Air and Soil Pollution 82:227-238.

Krankina, O. N. and M. E. Harmon. 1994. The impact of intensive forest management on carbon stores in forest ecosystems. The 5th Global Warming International Conference and Expo., San Francisco, April 4-7, 1994. World Resource Review 6(2):161-177.

Treyfeld, R.F., and Krankina, O.N. 2001. Estimating volume and biomass of woody detritus using forest inventory data (Opredelenie zapasov i fitomassy drevesnogo detrita na osnove dannyh lesoustroistva). Lesnoye Khoziajstvo 4: 23-26. (In Russian)

Yatskov, M. A. 2000. A chronosequence of wood decomposition in the boreal forests of Russia. MS thesis. Oregon State University, Corvallis, OR, pp. 168.

Questions? Email Dr. Mark Harmon at mark.harmon@orst.edu or Dr. Olga Krankina at olga.krankina@orst.edu

Back to the Main Page.

Return to the top of this page.