Does restoration fire enhance regeneration of deciduous trees in boreal forests?

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Outline

- Project framework
- (Boreal-) Forests & Fire
- Systematic Review
- Data Synthesis
- Results
- Conclusions

Project Framework

MISTRA EviEM

Council for Evidence based Environmental Management

- *Systematic review:*

  Active Management of Protected Areas

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Master- by research *2013-2015*

- *Systematic review:*

  Does restoration fire enhance the regeneration of deciduous trees in boreal forests

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Deciduous trees & Boreal forests

Small share of deciduous trees

~80% spruce and pine;~15% birch, aspen & alder (Forest Statistics, 2013)

- Aspen (*Populus*) and birches (*Betula*)
- Pioneer species Light dependent and not very competitive
- Key species for biodiversity

Aspen is considered the species with the most specific- associated epiphytes in the forests in Fennoscandia

"Sprucification" of the forests

- Silvicultural measures (e. g. planting of spruce, removal of aspen)
- High browser density
- Active fire suppression

→ dense forests:
not suitable for
aspen and birches

Effects of forest fires

- Removal of the ground vegetation and the understory of the forests
- Trigger the sprouting ability of aspen
- Create unique habitat for many, particular threatened species

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Systematic Review

"overview of **primary research** on a particular research question that tries to **identify**, **select**, **synthesize** and **appraise** all **high quality** research **evidence** relevant to that question in order to answer it"

Centre for evidence based Medicine, Oxford University

Special features:

- **Pre-defined** procedure
- **maximising transparency** and
- **minimising bias**

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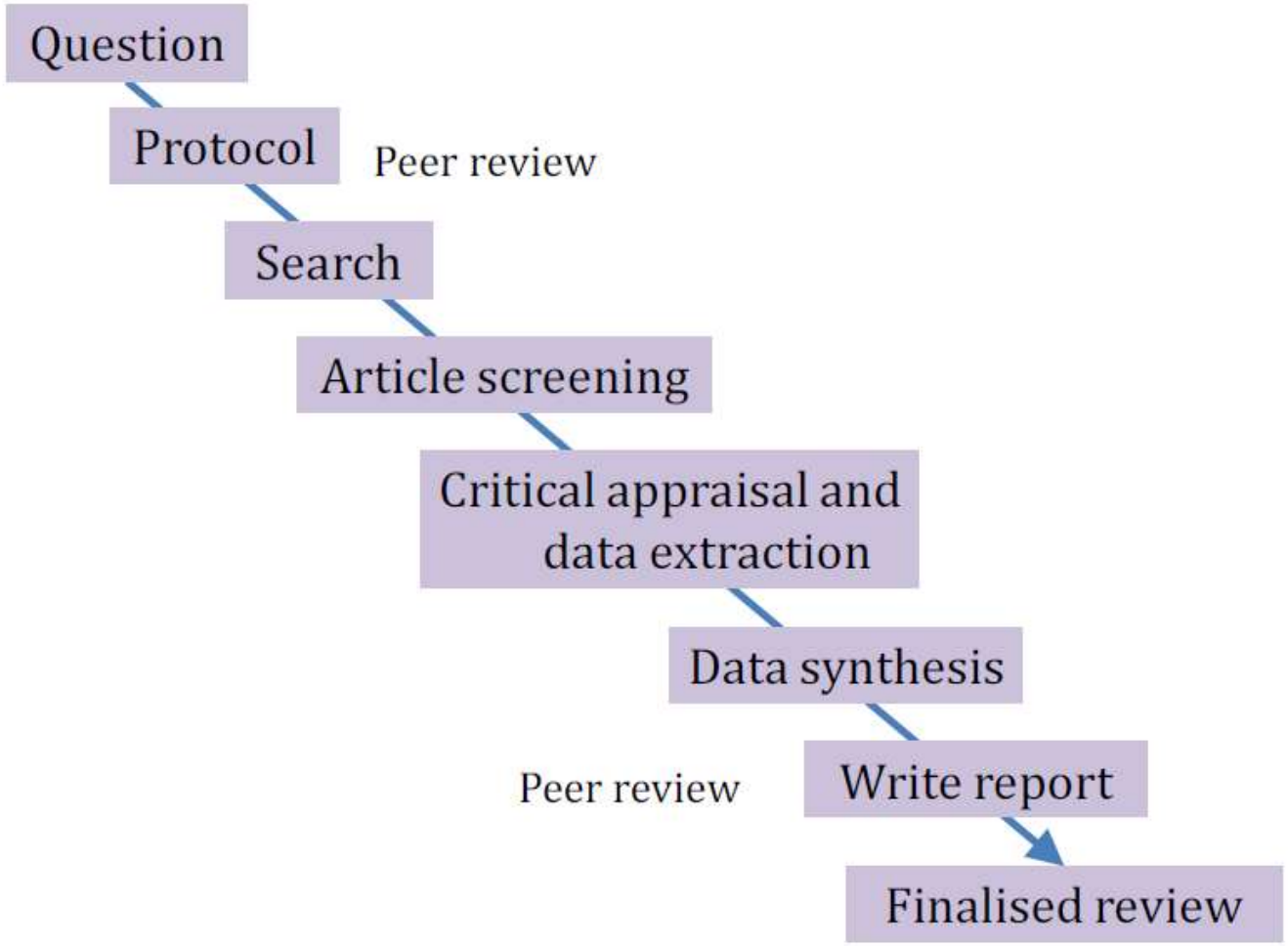
The Systematic Review Process



Basic steps in conducting a CEE systematic review

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Research Questions

1. Is there scientific evidence that fire affect boreal deciduous tree regeneration positively?
2. Which tree species benefit from fire?
3. Does fire affect vegetative and generative regeneration equally?
4. Does effects of fire change with treatment?
5. Is there an enduring effect of fire on deciduous tree regeneration?

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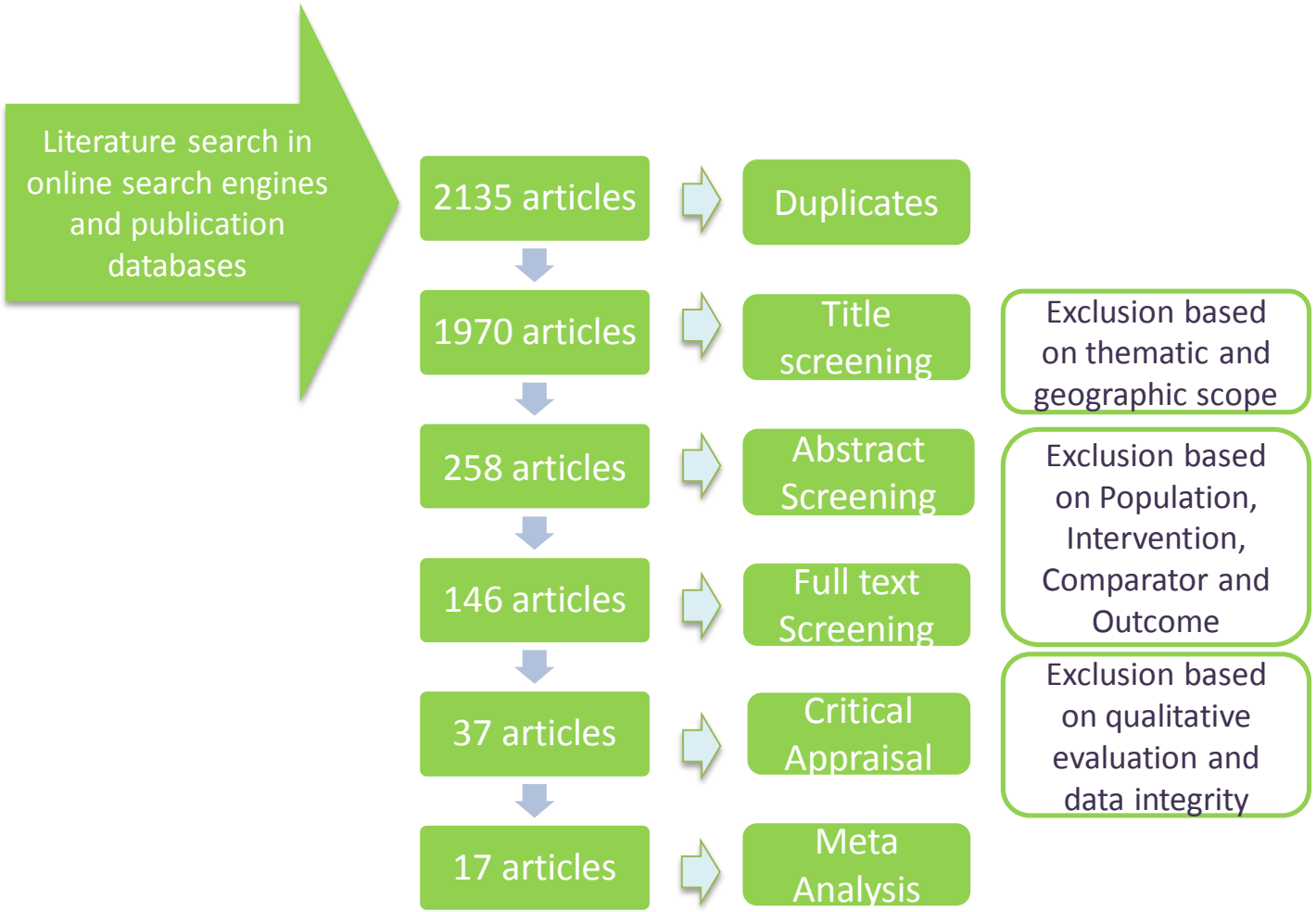
Article screening



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Critical Appraisal

To ensure the high quality of the studies

- Minimize bias introduced by study design
- Check for integrity (most common reason for exclusion: missing SD)

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Data Synthesis

Meta- Analysis

- Quantitative research synthesis
- Based on effect sizes
- Weighting the studies according to the inverse variance

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Effect sizes

Provide a standardised, directional measure of the mean change of a dependent variable

- Non-dimensional
- Independent of the data sources' unit

Standardize mean difference

Cohens' d and *Hedges' g*

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Data extraction

- Meta-data (Author, year, study location)
- Effect size data (2 means, variance, sample size)
- Study identifier (tree species, comparator, type of regeneration)
- Effect modifier

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Heterogeneity Analysis

- Cochrans' *Q: Compares the observed variance to that expected from sampling error*

  → High Q with a low associated p-value indicate the presence of heterogeneity; no information about the extent of the heterogeneity

- I^2*:* measures the extent of true heterogeneity

  → Can be interpreted as percentage of the total variability in the set of effect sizes due to true heterogeneity

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Relevant Studies

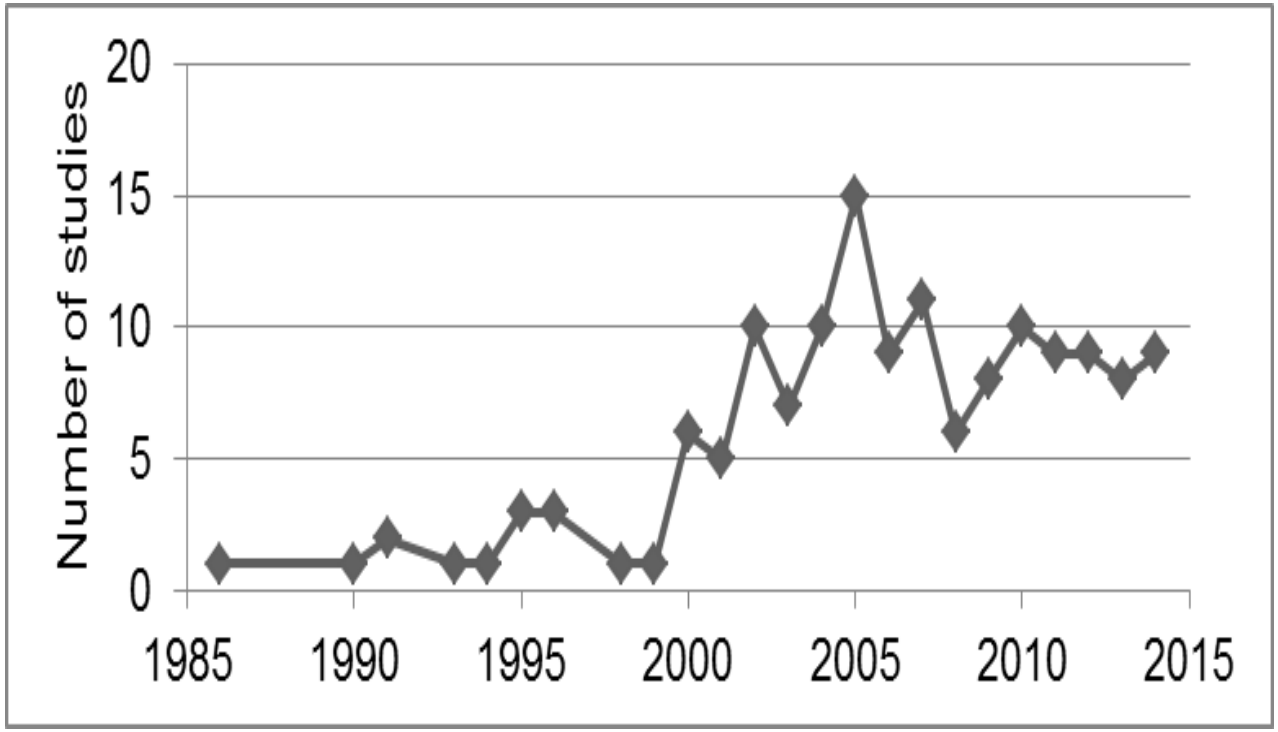

Fig. 1. Year of publication from studies that passed the abstract screening (n=146)

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Relevant Studies

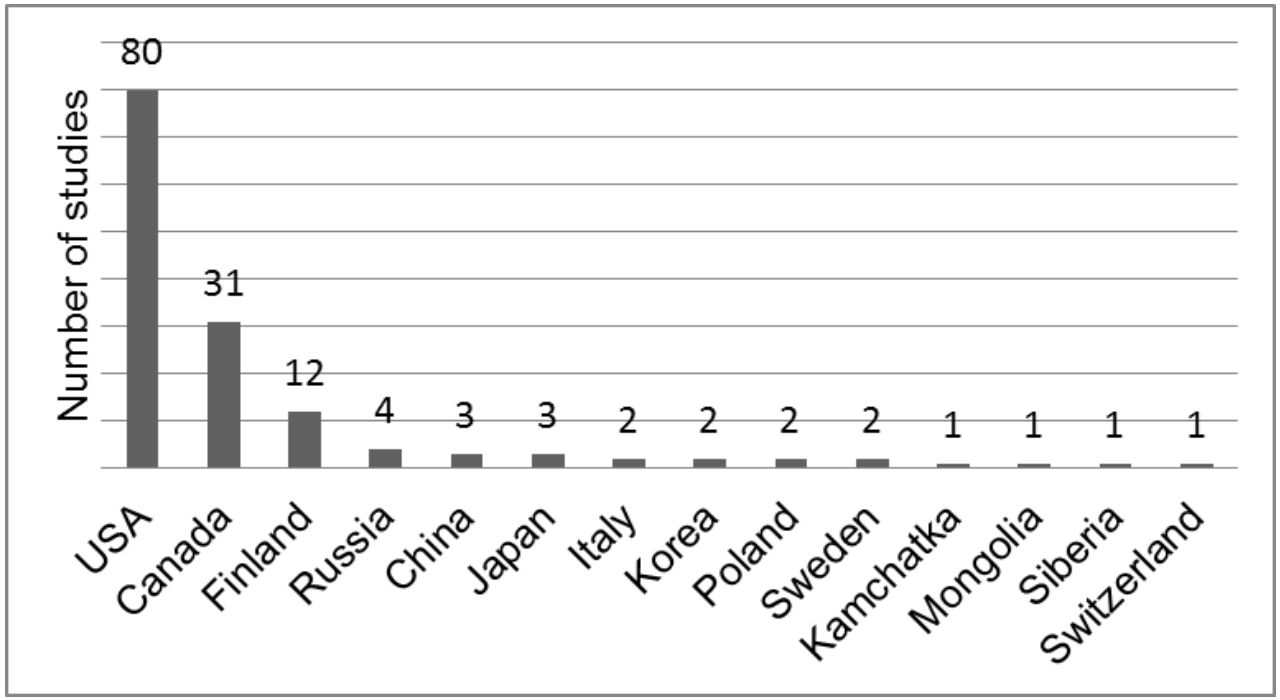

Fig. 2. Country of origin of studies that passed the abstract screening (n=146)

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Study distribution

Fig. 3. Distribution of the studies included in the meta-analysis (n=17)
A small star represent one study, a larger star, two studies.

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Publication bias

Duval and Tweedies trim and fill method:

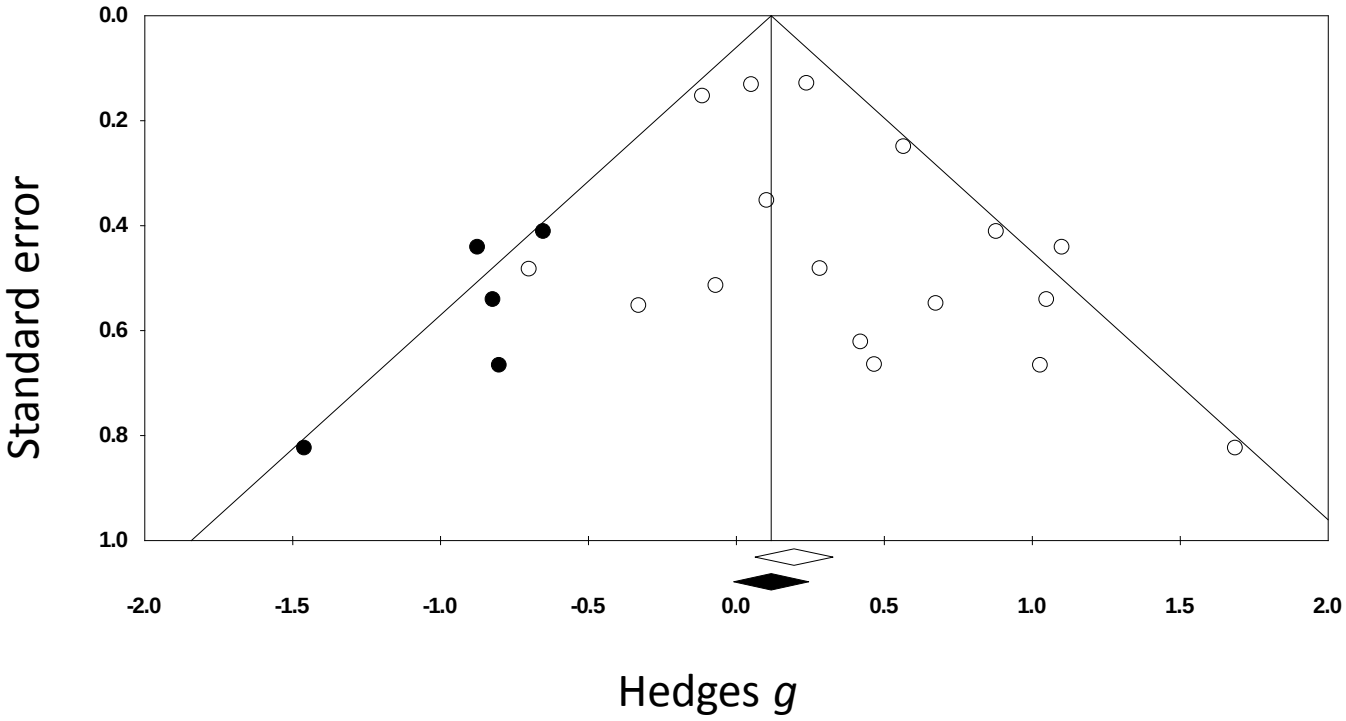

Fig. 4. Funnel plot of standard error by Hedges *g*.
Empty circles represent one study; filled circles show imputed studies

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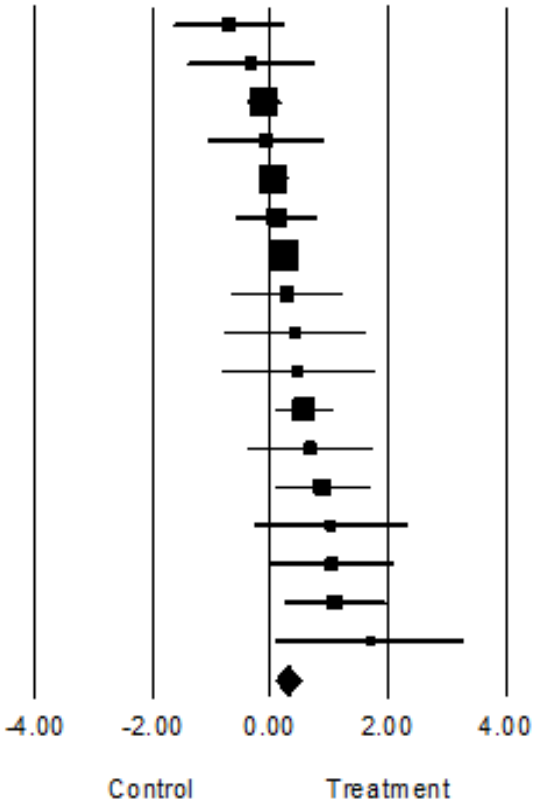
Forest Plot

For all species

Study name	Hedges's g	Standard error	Lower limit	Upper limit
Dolan 2004	-0.696	0.485	-1.647	0.255
Abrams2013	-0.325	0.555	-1.412	0.762
Ilisson 2009	-0.110	0.155	-0.414	0.195
Bartos 1994	-0.065	0.517	-1.077	0.948
Nuttle 2011	0.056	0.134	-0.207	0.318
Reyes 2010	0.108	0.355	-0.587	0.802
McGee 1995	0.242	0.131	-0.015	0.500
Romme 1995	0.287	0.484	-0.662	1.236
Wendel 1986	0.425	0.624	-0.798	1.648
Peltzer 2000	0.471	0.667	-0.837	1.779
Bartos 1991	0.570	0.252	0.076	1.063
Krasnow 2012	0.679	0.551	-0.400	1.758
Ojansivu 2014	0.883	0.414	0.072	1.694
de Chantal 2009	1.032	0.668	-0.278	2.342
Paragi 2006	1.053	0.543	-0.012	2.118
Wan 2014	1.105	0.444	0.236	1.975
Gom 2002	1.691	0.826	0.071	3.311
All studies	0.289	0.109	0.075	0.503



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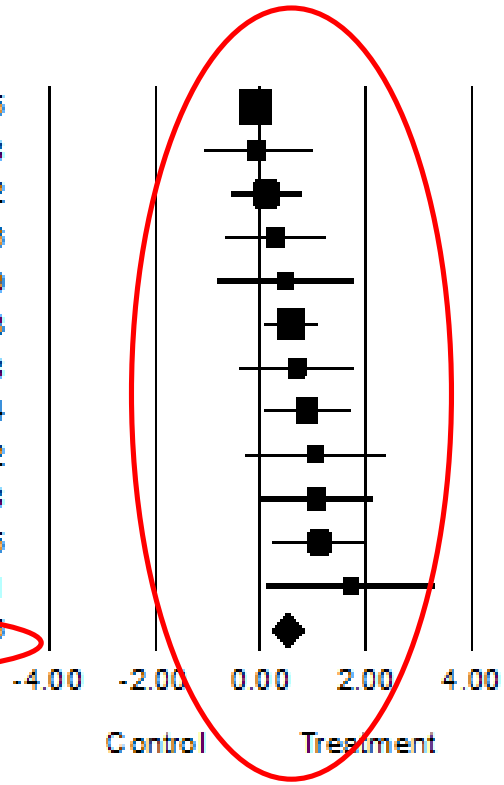
Forest Plot

for aspen & birches only

Study name	Hedges's g	Standard error	Lower limit	Upper limit
Ilisson 2009	-0.110	0.155	-0.414	0.195
Bartos 1994	-0.065	0.517	-1.077	0.948
Reyes 2010	0.108	0.355	-0.587	0.802
Romme 1995	0.287	0.484	-0.662	1.236
Peltzer 2000	0.471	0.667	-0.837	1.779
Bartos 1991	0.570	0.252	0.076	1.063
Krasnow 2012	0.679	0.551	-0.400	1.758
Ojansivu 2014	0.883	0.414	0.072	1.694
de Chantal 2009	1.032	0.668	-0.278	2.342
Paragi 2006	1.053	0.543	-0.012	2.118
Wan 2014	1.105	0.444	0.236	1.975
Gom 2002	1.691	0.826	0.071	3.311
All studies	0.501	0.165	0.177	0.825

Statistics for each study

Hedges's g and 95% CI



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Moderator Analysis

- Analysing effect sizes according to potential effect modifiers
- Testing structure for homogeneity/heterogeneity

Partitioning the effect sizes according to the moderators:

- Geographic distribution
- Forest association
- Shade tolerance
- Comparator
- Regeneration type
- Time since disturbance

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Moderator Analysis I

Tab. 1. Moderator Analysis for all included species

Modifier		-	±	+	Hedges *g* (CI)	*Q* (p, d.f.)	I^2	Sample size	k
Geographic location	East North America		X		0.026 (-0.173, 0.224)	11.710 (0.230, 9)	23.145	533; 304	7
	West North America			X	0.635 (0.322, 0.948)	5.834 (0.559, 7)	0.000	134; 65	8
	Finland			X	0.924 (0.235, 1.614)	1.551 (0.671,3)	0.000	13; 13	2
Between level				**X**		**14.385 (0.001, 2)**			**17**
Forest association	Oak		X		0.039 (-0.286, 0.363)	9.937 (0.127,6)	39.621	431; 197	5
	Aspen			X	0.428 (0.145, 0.711)	22.378 (0.071,14)	37.439	249; 185	12
Between level			**X**			**3.140 (0.076, 1)**			**17**
Shade-tolerance	Tolerant	X			-1.059 (-2.219,-1.791)	1.228 (0.268,1)	18.576	8; 5	2
	Intolerant			X	0.344 (0.124, 0.565)	25.493 (0.112,18)	29.394	553; 261	16
Between level				**X**		**5.434 (0.020, 1)**			**16***

Moderator Analysis I

Tab. 1. Moderator Analysis for all included species

Modifier		-	±	+
Geographic location	East North America		X	
	West North America			X
	Finland			X
Between level				**X**
Forest association	Oak		X	
	Aspen			X
Between level			**X**	
Shade- tolerance	Tolerant	X		
	Intolerant			X
Between level				**X**

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Moderator Analysis II

Tab. 2. Moderator Analysis for all included species

Modifier		-	±	+
Regeneration type	Generative		X	
	Vegetative			X
	Undefined		X	
Between level			**X**	
Comparator/ Control	Uncut		X	
	Thinning		X	
	Clearcut		X	
Between level			**X**	
Time since disturbance	1. year			X
	2-5 years			X
	6-19 years		X	
Between level			**X**	

Tab. 3. Moderator Analysis for aspen and birches

Modifier		-	±	+
Geographic location	East North America	X		
	West North America			X
	Finland			X
Between level				**X**
Regeneration type	Generative			X
	Vegetative			X
	Undefined		X	
Between level			**X**	
Comparator	Uncut			X
	Thinned			X
	Clearcut		X	
Between level				**X**
Time since disturbance	1. year			X
	2-5 years			X
	6-19 years		X	
Between level			**X**	

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Research Questions

Research question	Answered
Is there scientific evidence that fire affect boreal deciduous tree regeneration positively?	✓
Which tree species benefit from fire? Aspen, birches, shade intolerant species	✓
Does fire affect vegetative and generative regeneration equally?	✗
Does effects of fire change with treatment?	✓ *At least for aspen and birches
Is there an enduring effect of fire on deciduous tree regeneration?	✗

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Conclusion

- Fire has positive effect on the regeneration of boreal, deciduous tree species
- Regeneration success depends on multiple factors
- Further research is needed to identify influencing factors
- There is an urgent need for studies from Fennoscandia

Thank you for your attention!

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Moderator Analysis I

Tab. 1. Moderator Analysis for all included species

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Modifier		-	±	+	Hedges *g* (CI)	*Q* (p, d.f.)	I^2	Sample size	k
Geographic location	East North America		X		0.026 (-0.173, 0.224)	11.710 (0.230, 9)	23.145	533; 304	7
	West North America			X	0.635 (0.322, 0.948)	5.834 (0.559, 7)	0.000	134; 65	8
	Finland			X	0.924 (0.235, 1.614)	1.551 (0.671,3)	0.000	13; 13	2
Between level				**X**		**14.385 (0.001, 2)**			**17**
Forest association	Oak		X		0.039 (-0.286, 0.363)	9.937 (0.127,6)	39.621	431; 197	5
	Aspen			X	0.428 (0.145, 0.711)	22.378 (0.071,14)	37.439	249; 185	12
Between level			**X**			**3.140 (0.076, 1)**			**17**
Shade-tolerance	Tolerant	X			-1.059 (-2.219,-1.791)	1.228 (0.268,1)	18.576	8; 5	2
	Intolerant			X	0.344 (0.124, 0.565)	25.493 (0.112,18)	29.394	553; 261	16
Between level				**X**		**5.434 (0.020, 1)**			**16***

Moderator Analysis II

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Tab. 2. Moderator Analysis for all included species

Modifier		-	±	+	Hedges *g* (CI)	*Q* (p, d.f.)	I^2	Sample size	k
Regeneration type	Generative		X		0.233 (-0.095, 0.560)	11.507 (0.118,7)	39.167	434; 200	5
	Vegetative			X	0.562 (0.229, 0.896)	4.558 (0.602,6)	0.000	112; 59	7
	undefined		X		0.107 (-0.263, 0.477)	11.914 (0.103,7)	41.243	138, 127	6
Between level			**X**			**3.622 (0.163, 2)**			**17**
Comparator/ Control	Uncut		X		0.271 (-0.035, 0.577)	21.190 (0.048, 12)	43.369	510; 229	11
	Thinning		X		0.414 (-0.237, 1.065)	10.796 (0.095, 6)	44.423	27; 29	4
	Clearcut		X		0.113 (-0.189, 0.415)	5.798 (0.215, 4)	31.010	153; 134	4
Between level			**X**			**0.923 0.630, 2**			**17**
Time since disturbance	1. year			X	0.703 (0.082, 1.324)	7.01 (0.220, 5)	28.650	57; 22	5
	2-5 years			X	0.398 (0.022, 0.774)	18.607 (0.098, 12)	35.508	154; 71	11
	6-19 years		X		0.164 (-0.032, 0.360)	11.423 (0.179, 8)	29.969	570; 323	6
Between level			**X**			**3.037 (0.219,2)**			**17**

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Tab. 3. Moderator Analysis for aspen and birches

Modifier		-	±	+	Hedges *g* (95% CI)	*Q* (p, d.f.)	I^2	Sample size	k
Geographic location	East North America	X			-0.075 (-0.354, -0.204)	0.500 (0.779, 2)	0.000	102; 107	2
	West North America			X	0.635 (0.322, 0.948)	5.834 (0.559, 7)	0.000	134; 65	8
	Finland			X	0.924 (0.235, 1.614)	1.551 (0.671, 3)	0.000	13;13	2
Between level				**X**		**14.493 (0.001, 2)**			**12**
Regeneration type	Generative			X	0.883 (0.072,1.694)*	1.515 (0.469, 2)	0.000	9; 9	1
	Vegetative			X	0.613 (0.040, 1.186)	10.198(0.070, 5)	50.969	107; 55	6
	Undefined		X		0.221 (-0.174, 0.616)	9.395 (0.094, 5)	46.782	132; 121	5
Between level			**X**			**2.848 (0.241, 2)**			**12**
Comparator	Uncut			X	0.720 (0.220, 1.221)	6.175 (0.290,5)	19.022	79; 32	6
	Thinned			X	0.854 (0.301, 1.406)	1.870 (0.760,4)	0.000	21; 23	3
	Clearcut		X		0.113 (-0.189, 0.415)	5.798 (0.215, 4)	31.010	153;134	4
Between level				**X**		**7.592 (0.022, 2)**			**12**
Time since disturbance	1. year			X	0.991 (0.116, 1.866)	5.486 (0.140, 3)	45.31	51; 16	4
	2-5 years			X	0.691 (0.287, 1.096)	3.508 (0.480, 6)	0.000	86,41	7
	6-19 years		X		0.225 (-0.121, 0.571)	10.431 (0.108, 6)	42.480	159;140	4
Between level			**X**			**4.525 (0.104, 2)**			**12**