Final report for Centre of Advanced Research (CAR)

Submit the report to sns@slu.se by 23:59 CET, 1st of March 2022, at the latest.
The report should not exceed 4500 words (including words in the template).

Please adjust the size of the box according to the length of your answer.

1. Project title:	Centre of Advanced Research in Forest Health and Forest Genetics to Enhance Bioeconomy (HealGenCAR)
2. Reporting year:	2016-2021

3. Project coordinator:	Tuija Aronen
Email:	tuija.aronen@luke.fi
Address:	Vipusenkuja 5, FI-57200 Savonlinna, Finland

Activity report

4. Provide a project summary, including:

a) The purpose of the project/main problems /hypothesis addressed

The overall objective of HealGenCAR was to support development and implementation of good practices for use and management of forest genetic resources, as well as pest and disease management to the benefit of Nordic countries. The specific objective of HealGenCAR was to enhance a Nordic research environment by continuing the long tradition of collaboration in forest genetics, pathology, entomology and breeding in the Nordic region. The network also included researchers from Baltic countries and linked closely to new or on-going activities within the field in Europe.

b) A short description of the main activities of the project

The project has organized two conferences (+ one jointly with NordGen), six workshops, two meetings and one training session. In addition, the project has supported two excursions and one study visit. Three policy briefs have been produced in the project, and web-pages were created and updated. Three videos were produced on different topics of pathology and entomology, as well as three videos for the Workshop on Vegetative Propagation. Six applications for funding have been prepared in the networks created in HealGenCAR.

c) Achieved targets and to what extent the research plan was fulfilled

The targets were achieved and all (except QPCR workshop in Norway) of the activities mentioned in the workplan of HealGenCAR were realized before year 2020. In addition to the activities in the realization plan, several applied activities were carried out (2 meetings, 3 workshops, 2 excursions).

The covid-19 pandemia in 2020 caused major changes in the program of the last year. The final conference, "Epigenetics and its significance and potentials for adaptation and resistance of trees" could not be arranged. The workshop on vegetative propagation of conifers was first postponed and then arranged as a webinar, which eventually received much more attention than the originally planned meeting on the spot at Savonlinna. The applied activity "Excursion in damaged Northern forests" could not be arranged. Two study visits (James Doonan, Sara Piqueras) were also cancelled. As an extra activity, however, the participating countries produced videos of topical issues in pathology, entomology and breeding on the money that was saved from meetings face-to-face.

5. Published outputs achieved as a consequence of the project (peer-reviewed articles, other publications)

Selected examples of the publications produced:

Ahtikoski, A., Karhu, J., Ahtikoski, R., Haapanen, M., Hynynen, J., Kärkkäinen, K. 2020. Financial assessment of alternative breeding goals using stand-level optimization and data envelopment analysis. Scandinavian Journal of Forest Research 35(5-6): 262-273.

Alonso-Serra, J., Shi, X., Peaucelle, A., Rastas, P., Bourdon, M., Immanen, J., Takahashi, J., Koivula, H., Eswaran, G., Muranen, S., Help, H., Smolander, O-P.Su, C., Safronov, O., Gerber, L., Salojärvi, J., Hagqvist, R., Mähönen, A.P.,Helariutta, Y., Nieminen, K. 2020. ELIMÄKI Locus Is Required for Vertical Proprioceptive Response in Birch Trees. Current biology 30(4): 589-599.

Adamson, K., Mullett, M.S., Solheim, H., Barnes, I., Müller, M. M., Hantula, J., Vuorinen, M., Kacergius, A., Markovskaja, S., Musolin, D., Davydenko, K., Keča, N., Ligi, K., Priedite, R.D., Millberg, H., Drenkhan, R. 2018. Looking for relationship between the populations of *Dothistroma septosporum* in northern Europe and Asia. Fungal Genet. Biol. 110, 15-25; doi: 10.1016/j.fgb.2017.12.001.

Andersson, G. B., Persson T., Fedorkov, A., Mullin, T.J. 2018. Longitudinal differences in Scots pine shoot elongation. Silva Fennica vol. 52 (5). article id. 10040. 12 p. https://doi. org/10.14214/sf.10040

Benavides, R. et al. 2021. The GenTree Leaf Collection: Inter- and intraspecific leaf variation in seven forest tree species in Europe. Global ecology and biogeography 30 (3): 590-597.

Berlin, M., Persson, T., Jansson, G., Haapanen, M., Ruotsalainen, S., Bärring, L., Andersson, G.B. 2016. Scots pine transfer effect models for growth and survival in Sweden and Finland. Silva Fennica 50(3):21 p.

Botella, L., Hantula, J. 2018. Description, distribution and relevance of viruses of the forest pathogen *Gremmeniella abietina*. Viruses 2018, 10, 654; doi:10.3390/v10110654.

Calleja-Rodriguez, A., Andersson, G.B., Wu H. X., Mullin T. J. & Persson T. 2019. Genotype-by-environment interactions and the dynamic relationship between tree vitality and height in northern Pinus sylvestris. Tree Genetics & Genome 15:36. https://doi.org/10.1007/s11295-019-1343-8

Chen, Z.Q., Lunden, K., Karlsson, B., Vos, I., Olson, A., Lundqvist, S.O., Stenlid, J., Wu, H. X., Gil, M.R.G., Elfstrand, M. 2018. Early selection for resistance to *Heterobasidion parviporum* in Norway spruce is not likely to adversely affect growth and wood quality traits in late-age performance. European Journal of Forest Research 137: 517-525

Desprez-Loustau, M.L. et al. 2018. From leaf to continent: The multi-scale distribution of an invasive cryptic pathogen complex on oak. Fungal Ecology 36:39-50. DOI: 10.1016/j.funeco.2018.08.001

Di, B., Luoranen, J., Lehto, T., Himanen, K., Silvennoinen, M., Silvennoinen, R., Repo, T. 2019. Biophysical changes in the roots of Scots pine seedlings during cold acclimation and after frost damage. Forest Ecology and Management 431: 63-72.

Edesi, J., Tikkinen, M., Elfstrand, M., Olson, Å., Varis, S., Egertsdotter, U., Aronen, T. 2021. Root Rot Resistance Locus PaLAR3 Is Delivered by Somatic Embryogenesis (SE) Pipeline in Norway Spruce (*Picea abies* (L.) Karst.). Forests 12 (2): 10 p.

Ekholm, A., Tack, A. J. M., Pulkkinen, P., Roslin, T. 2019. Host plant phenology, insect outbreaks and herbivore communities – The importance of timing. Journal of Animal Ecology: 89(3): 829-841.

Elvira-Recuenco, M. et al. 2020. Potential interactions between invasive *Fusarium circinatum* and other pine pathogens in Europe. Forests 11, 7

Erbilgin, N., Klutsch, J. G., Najeeb, H., Cale, J. A., Ishangulyyeva, G., Rajabzadeh, R., Boone, C., Bozic, T., Jansson, G., Haapanen, M., Hughes, C., MacQuarrie, C. J. K., Schroeder, M., Seppo, R. 2020. Chemical similarity between

introduced and native populations of Scots pine can facilitate transcontinental expansion of mountain pine beetle in North America. Biological Invasions 22: 1067-1083.

Hamberg, L., De la Bastide, P, Hintz, W., Shamoun, S.F., Brandtberg, M. & Hantula, J. 2018. Interfertility and genetic variability among European and North American isolates of the basidiomycete fungus *Chondrostereum purpureum*. Fungal Biol. 122: 659-667. doi: 10.1016/j.funbio.2018.03.009.

Hayatgheibi, H., Berlin, M., Haapanen, M., Kärkkäinen, K., Persson, T. 2020. Application of Transfer Effect Models for Predicting Growth and Survival of Genetically Selected Scots Pine Seed Sources in Sweden. Forests 11 (12): 10 p.

Hayatgheibi, H., Haapanen, M., Lundströmer, J., Berlin, M., Kärkkäinen, K., Helmersson, A., 2021. The Impact of Drought Stress on the Height Growth of Young Norway Spruce Full-Sib and Half-Sib Clonal Trials in Sweden and Finland. Forests 12 (4): 15 p.

Hussain, Z., Rasheed, F., Tanvir, M. A., Zafar, Z., Rafay, M., Mohsin, M., Pulkkinen, P., Ruffner, C. 2021. Increased antioxidative enzyme activity mediates the phytoaccumulation potential of Pb in four agroforestry tree species: a case study under municipal and industrial wastewater irrigation. International Journal of Phytoremediation 21(7): 704-714.

Hyder, R., Piri, T., Hantula, J., Nuorteva, H. & Vainio, E.J. 2018. Distribution of viruses inhabiting *Heterobasidion annosum* in a pine-dominated forest plot in southern Finland. Micr. Ecol. 75: 622-630. doi: 10.1007/s00248-017-1027-6.

Jansson, G., Kehlet Hansen, J., Haapanen, M., Kvaalen, H., Steffenrem, A. 2017. The genetic and economic gains from forest tree breeding programmes in Scandinavia and Finland. Scandinavian Journal of Forest Research 32(4):273-286. DOI: 10.1080/02827581.2016.1242770

Kimberley, T. D., Callaway, R.M., Fajardo, A., Pauchard, A., Nuñez, M. A., Brooker, R.W., Maxwell, B.D., Dimarco, R.D., Peltzer, D.A., Mason, B., Ruotsalainen, S., McIntosh, A.C.S., Pakeman, R.J., Smith, A. L., Gundale, M.J. 2018. Severity of impacts of an introduced species corresponds with regional eco-evolutionary experience. Ecography 42: 11.

Klapwijk, M.J., Boberg, J., Bergh, J., Bishop, K., Björkman, C., Ellison D., Felton, A., Lidskog, R., Lundmark, T., Keskitalo, E.C.H., Sonesson, J., Nordin, A., Nordström, E-M., Stenlid, J., Mårald, E. 2018. Capturing complexity: Forests, decision-making and climate change. Global Environmental Change 52: 238-247.

Kosawang, C., Amby D.B., Bussaban B., McKinney, L.V., Xu, J., Kjær E.D., Collinge D.B., Nielsen, L.R. 2018. Fungal communities associated with species of *Fraxinus* tolerant to ash dieback, and their potential for biological control. Fungal Biology 122(2-3): 110-120.

Kosawang C., Sørensen H., Kjær E.D., Dilokpimol A., McKinney L.V., Collinge D.B., Nielsen L.R. 2019. Defining the twig fungal communities of *Fraxinus* species and *Fraxinus excelsior* genotypes with differences in susceptibility to ash dieback. *Fungal Ecology* 42: 100859.

Lee, D., Beuker, E., Viherä-Aarnio, A., Hynynen, J. 2021. Site index models with density effect for hybrid aspen (*Populus tremula* L. × *P. tremuloides* Michx.) plantations in southern Finland. Forest Ecology and Management 480: 12 p.

Levkoev, E., Mehtätalo, L., Luostarinen, K., Pulkkinen, P., Zhigunov, A., Peltola, H. 2018. Development of height growth and frost hardiness for one-year-old Norway spruce seedlings in greenhouse conditions in response to elevated temperature and atmospheric CO_2 concentration. Silva Fennica 52(3): 15 p.

Lindelöw, Å., Isacsson, G., Ravn, H.P., Schroeder, M. 2015. *Tetropium gabrieli* and *Ips cembrae* (Coleoptera; Cerambycidae and Curculionidae) – invasion of two potential pest species on larch in Sweden. Entomologisk Tidskrift 136 (3): 103–112. Uppsala, Sweden. ISSN 0013-886x.

Marčiulynienė, D., Davydenko, K., Stenlid, J., Shabunin, D., Cleary, M. 2018. *Fraxinus excelsior* seed is not a probable introduction pathway for *Hymenoscyphus fraxineus*. Forest Pathology 10.1111/efp.12392

Moreira, X., Abdala-Roberts, L., Bruun, H.H., Covelo, F., De Frenne, P., Galmán, A., Gaytán, Á., Jaatinen, R., Pulkkinen, P., Ten Hoopen, J.P.J.G, Timmermans, B.G.H., Tack, A. J. M., Castagneyrol, B. 2020. Latitudinal variation in seed predation correlates with latitudinal variation in seed defensive and nutritional traits in a widespread oak species. Annals of Botany 125(6):881–890.

Muñoz-Adalia, E.J., Diez, J.J., Fernández, M.M., Hantula, J. & Vainio, E.J. 2018. Characterization of small RNAs originating from mitoviruses infecting the conifer pathogen *Fusarium circinatum*. Arch. Virol. 163: 1009-1018; doi: 10.1007/s00705-018-3712-2.

Myking, T., Rusanen, M., Steffenrem, A., Dahl, K.E., Jansson, G. 2016. Historic transfer of forest reproductive material in the Nordic region: drivers, scale and implications. Forestry 89(4): 325-337.

Müller, M. M., Hamberg, L., Hantula, J. 2016. The susceptibility of European tree species to invasive Asian pathogens: a literature-based analysis. Biological Invasion 18: 2841-2851. Doi: 10.1007/s10530-016-1174-6

Nissinen, K., Virjamo, V., Randriamanana, T., Sobuj, N., Sivadasan, U., Mehtätalo, L., Beuker, E., Julkunen-Tiitto, R., Nybakken, L. 2017. Responses of growth and leaf phenolics in European aspen (*Populus tremula*) to climate change during juvenile phase change. Can. J. For. Res. 47: 1350–1363 (2017). dx.doi.org/10.1139/cjfr-2017-0188

Poimala, A., Werres, S., Pennanen, T. & Hantula, J. 2018. First report of alder *Phytophthora* closely related to *P. uniformis* on an *Alnus glutinosa* seedling in Finland. Plant Dis.102, 454; doi: 10.1094/PDIS-03-17-0322-PDN.

Redondo, M.A., Boberg, J., Stenlid, J., Oliva, J. 2018. Functional traits associated with the establishment of introduced *Phytophthora* spp. in Swedish forests. Journal of Applied Ecology DOI: 10.1111/1365-2664.13068

Rogers, P.C.; Pinno, B. D., Šebesta, J. Albrectsen, B.R.,Li, G., Ivanova, N., Kusbach, A., Kuuluvainen, T., Landhäusser, S.M.; Liu, H., Myking, T., Pulkkinen, P., Wen, Z., Kulakowski, D. 2020. A global view of aspen: Conservation science for widespread keystone systems. Global Ecology and Conservation 21: 20 p.

Semizer-Cuming D., Finkeldey R., Nielsen L.R., Kjær E.D. 2019. Negative correlation between ash dieback susceptibility and reproductive success: good news for European ash forests. Annals of Forest Science 79:16.

Tikkinen, M., Varis, S., Aronen, T. 2018. Development of Somatic Embryo Maturation and Growing Techniques of Norway Spruce Emblings towards Large-Scale Field Testing. Forests 9 (6): 325.

Turunen, M., Urbano-Tenorio, F., Rasa, K., Hyväluoma, J., Rytkönen, P., Kaseva, J., Beuker, E., Suhonen, H., Jyske, T. 2021. How clonal differences and within-tree heterogeneity affect pore properties of hybrid aspen wood and biochar? Biomass conversion and biorefinery: https://doi.org /10.1007/s13399-021-01464-3

Zamora-Ballesteros, C. et al. 2019. Pine Pitch Canker (PPC): pathways of disease spread and preventive measures. Forests 10: 1158

Zeps, M., Jansons, A., Matisons, R., Stenvall, N., Pulkkinen, P. 2017. Growth and cold hardening of European aspen seedlings in response to an altered temperature and soil moisture regime. Agricultural and Forest Meteorology 242: 47-54.

Other publications:

-Can genetics save our forests from pests and pathogens? News and Views, Scandinavian Journal of Forest Research, vol. 31, 2016.

-Kasvit liikkuvat ja niiden mukana taudit, Puruvesi (local paper from the Punkaharju area) 16.6.2016. Article on the first HealGenCAR conference in Punkaharju.

6. Other practical outputs of the project (websites, policy recommendations, conferences, scientific meetings, large-scale project applications, research training etc.)

HealGenCAR project produced the following outputs:

Website was created and updated.

Policy briefs:
1.What should we do to protect Nordic forests from climatic change and alien pests and pathogens?
2.How can we prepare Nordic forests for the future?
3.Enhancing the resilience of Nordic forests – aided by microbiota, epigenetics and tree breeding

Conferences:
1.Challenges in resistance breeding June 7-9, 2016, Punkaharju, Finland
2.Clonal forestry and breeding for resistance June 12-14, 2018, Höör, Sweden
3.The conference "Early detection and mitigation of invasive pests and diseases in Nordic forests, September 17-18, 2019, Hveragerði, Iceland" was organized as a joint activity with NordGen.

Workshops:
1.Nordic-Baltic Forest Entomological group, November 16-17, 2016, Copenhagen, Denmark.
2.Hybrid aspen and poplar breeding, February 7-8, Helsinki, Finland
3.Fighting ash dieback with new and old tools, August 23-25, 2017, Denmark
4.Future forest health, September 16, 2019, Hveragerði, Iceland
5.Seed orchard management, September 11-12, 2019, Jyväskylä, Finland
6.A joint HealGenCAR – MULTIFOREVER Workshop: Multiplied conifer seed – prospects of somatic embryogenesis, May 26-27, 2021, Savonlinna, Finland – WEBINAR

Meetings:
1.Tree breeders in Fennoscandia and the Baltic states, April 19-20, 2017, Riga, Latvia
2.Forests and fields in climate change, March 18-19, 2019, Oulu, Finland

Excursions:
1.A short-term scientific mission to Russia on ash dieback and the emerald ash borer, May 4-7, 2017, Russia
2.Silvicultural field trip of Silviculture club of Finnish Society of Forest Science to central Sweden, September 23-24, 2019, Sweden

Training:
1.Training session on using R and on genetic data analysis using SNP data for relationship (GBLUP), November, 14-17, 2017, Umeå, Sweden

Project applications:
1.Wood Biomass Production in Medium Rotation Plantations with Hybrid Aspen and Poplars (MedRoPlan); Baltic Sea Region Interreg call, obtained financing
2.Adaptive BREEDING for productive, sustainable and resilient FORESTs under climate change; H2020-BB-2016-2017 (Bio-based innovation for sustainable goods and services) call, obtained financing
3.Tandem ForestValues SOMAGENO (Luke and SLU) financing obtained from KSLA, Sweden
4.ERA-NET Forest Value project MULTIFOREVER obtained financing
5.Application to Horizon 2020 "Tackling emerging threats to European forests using biocontrol & genomic solutions" (Finland, Sweden, Norway)
6.Project application was developed "Adaptability of Fraxinus excelsior from different European sources" as a result of the visit of Miguel Nemesio-Gorriz to Denmark

Support to study trips and research exchange:

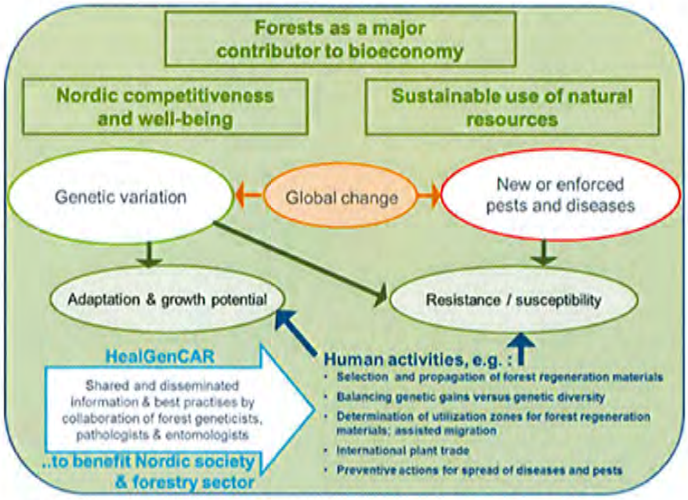
Visit by Miguel Nemesio-Gorriz from Teagasc, Ireland to Denmark in May 13-15, 2019, concerning ash-dieback

Videos:

1.HealGenCAR and importance of co-operation (Finland)
2.Ash die-back (Denmark)
3.Heterobasidion (Sweden and Finland)
4.Videos for the webinar: Savonlinna technological platform and field trials

7. How and within which areas was the project beneficial for the Nordic countries?

The HealGenCAR project has brought together two separate but related disciplines: forest genetics including applied tree breeding and forest health issues including both forest entomology and pathology. The global change affects all these and creates a framework in which joining of forces is needed in order to secure well-being of our forests, as seen in the Figure. The Nordic countries share already to large extent the same species, conditions and problems, and global change does not recognize any borders. Therefore, compiling data together, dissemination of information and the best practices is beneficial. In order to realize this, we have been able to organize courses, meeting and workshops, in which people working in Nordic countries have been able to get to know each other, share experiences and views. This has resulted in in cross-pollination of ideas and joint applications. As an outcome, collaborative research projects have not only provided new scientific information but also supported competence building. At the same time, we think that together we have been better able to raise awareness of stakeholders and decision makers than if separate viewpoints from narrower disciplines would have been brought up.



Participation

8. Number of participants

Country	Young researchers / PhD students	Senior researchers	Stakeholders	Others (specify)	Gender			Total
					Women	Men	Other	
Denmark	5	20	3		7	21		28
Finland	10	97	20		60	67		127
Iceland	5	19	18		17	25		42

Norway	1	11	6		4	14		18
Sweden	8	70	35		28	85		113
Estonia	1	3				4		4
Latvia		2	1			3		3
Lithuania		1	1			2		2
25 other countries	Argentina, Austria, Brasil, China, Canada	Chile, Cuba, Chez Republic, Germany, Spain, France, Iran,	Israel, Mexico, New Zealand, Poland, Portugal Repub. of Korea Russia	Turkey, UK, USA, Ireland, South Africa, Netherlands				168
Total	30	223	84		116	221		505

9. List the participating institutes/sectors
Natural Resources Institute Finland (Luke) (koordinator) Skogforsk, Sweden Swedish University of Agricultural Sciences (SLU) University of Copenhagen, Denmark Norwegian Institute on Bioeconomy Research Icelandic Forest Reseach In addition, dozens of stakeholders (research institutes, universities and forestry organizations) have participated in the events organized by HealGenCAR.

Economic report

10. Received grant from SNS in total (SEK):
2 250 000 + 94 313,64 sek (= 9836,12 € from AdapCAR) = 2 344 313,64 SEK

11. Transfer of SNS funds to project partners

Country	Partner organization	Sum (SEK)
Denmark	Kobenhavns universitetet	307 588
Finland	Luke	1 243 233,62
Finland	SiemenForelia & Finn. Soc. For. Sci.	126 506,07
Sweden	SLU	156 839,62
Sweden	Skogforsk	207 630,86
Norway	NIBIO	5 5362,65
Iceland	Skogsraekt rikisins Mogilsa	145 584,11
Other countries (specify)	South Africa + 3 students in 2018	19 404,73
Total SUM		**2 262 149,58**

12. Costs

	SNS funding	External funds*	Total*
Travel and hotel	322 438,76		
Meeting costs	716 697,67		
Consumables			
Salary	676 203,18		
Communication	423 267,56		
Other costs (national coordination)	123 542,41		
Total SUM (SEK)	**2 262 149,58**	**460 000 000**	**462 262 149,58**

* If possible, provide details otherwise summarize the total sum for external funds and total.

13. Economic result (deficit or surplus):

Surplus 82 164, 06 SEK

Optional: Comments to the economic reporting:

The economy report is based on exchange rate 1 € = 9,5885 SEK (on December 7, 2021, at 11:00 a.m), which was used for the years, in which the annual report had been given in euros. Total sums of external funding and overall total are rough estimates, since it was not possible to get detailed information as already explained in the annual reports

14. Submit a policy brief as a separate document. Provide pictures (size at least 500x500 pixels and resolution at least 72 pixels) in the policy brief as well as separate files (.jpg). Include caption to each picture, and the name of photographer.

I hereby declare that the above statements are true to the best of my knowledge

Main applicant's signature, place and date

Tuija Aronen

Tuija Aronen Natural Resources Institute Finland 22.12.2021

Signature of the head of the main applicant's research institution

Anu Kaukovirta	Natural Resources Institute Finland	10.1.2022

Anu Kaukovirta, Vice President

Second applicant's signature, **place and date**

BRYNJA HRAFNKELSD.	Icelandic Forest Service	20/12/2021
(Signature)	(Institution)	(Day / Month / Year)

Third applicant's signature, **place and date**

(Signature)	(Institution)	(Day / Month / Year)

Signature of the head of the main applicant's research institution

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(Signature)	(Institution)	(Day / Month / Year)

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(Printed name, function)

Second applicant's signature, place and date

	NIBIO	14.12.2021
(Signature)	(Institution)	(Day / Month / Year)

Third applicant's signature, place and date

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Signature of the head of the main applicant's research institution

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(Signature)	(Institution)	(Day / Month / Year)

.....
(Printed name, function)

Second applicant's signature, place and date

Lene R. Nielsen	University of Copenhagen	15-12-2021
.....	.....	.....
(Signature)	(Institution)	(Day / Month / Year)

Third applicant's signature, place and date

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(Signature)	(Institution)	(Day / Month / Year)