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Data and R-code for the publication Projected wind energy on forest land – A land use transition trajectory to reach 100% renewable energy goal in Sweden

The present data set consists of two zipped folders of which one includes 14 data files and one documentation file (READ_ME), and the other one 13 associated codes and the documentation file (READ_ME).

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R session

R (version 4.1.2 and 4.3.2) was used for spatial analyses, data handling and visualization.
Used packages:

- library(dplyr) – version 1.1.3 (R version 4.3.2)
- library(ggplot2) – version 3.5.1 (R version 4.3.2)
- library(raster) – version 3.6-26 (R version 4.1.2)
- library(readr) – version 2.1.5 (R version 4.3.2)
- library(readxl) – version 1.4.3 (R version 4.1.2)
- library(rgeos) – version 0.5-9 (R version 4.1.2)
- library(rgdal) – version 1.5-32 (R version 4.1.2)
- library(sf) – version 1.0-14 (R version 4.1.2)
- library(sp) – version 2.1-1 (R version 4.1.2)

References

ER (2021). National strategy for a sustainable expansion of wind power establishment (www.energimyndigheten.se). Report produced by *the Swedish Energy Agency* in cooperation with the *Swedish Environmental Protection Agency* 2021:2. ISBN (pdf) 978-91-89184-88-6. https://www.energimyndigheten.se/globalassets/fornybart/strategi-for-hallbar-vindkraftsutbyggnad/er-2021_02.pdf [In Swedish, Original title: Nationell strategi för hållbar vindkraft. (ER 2021:2). Energimyndigheten]

Neumann, W., Bjärstig, T. & Svensson, J. (2026). Projected wind energy on forest land – A land use transition trajectory to reach 100% renewable energy goal in Sweden. *Sustainable Environment* 12: 2616124. https://doi.org/10.1080/27658511.2026.2616124

Objective

To realize the goal of 100% renewable energy production by 2040, the Swedish Energy Agency presented a national strategy for large-scale wind energy development to advance the sustainable expansion of onshore wind energy (ER 2021). The strategy relies on a minimum of 80 TWh additional onshore production with region-specific energy production directives. Based on these regional expansion goals, we developed a 2040 projection based on the status of onshore wind energy in 2022 and the expected future (2040) production capacity on forest land. To advance sustainable planning premises, we explored how future wind energy expansion may affect different categories of forest (forests used for forestry, woodland, and forests with high conservation value (HCVF)) and forest owners (state, company and private (NIPF)) within and in proximity to wind energy sites in ecoregions and counties.

Description

The data files and code files are connected to the analyses and findings in the present open-source publication (Neumann et al. 2026). Detail description of the methodology and processing of the data can be found in the Materials and methods section.

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Code files

The names of the code files are systematically built and encode the analysis target and associated figure or table. Coding language is linked to the programming software R (version 4.4.1, https://cran.r-project.org/)

- Prep: Data handling and preparation code
- Figure: code to generate the information given in the corresponding figure in the publication
- Table: code to generate the information given in the corresponding table in the publication
- App: code to generate the information given in the corresponding appendix in the publication

List of code files

- Prep_GenerateParks_site_scaled
- Prep_GenerateParks_3ggr_scaled
- Figure2_windForestland_2022_2040_tsv
- Figure3_changeForestLand_tsv
- Figure4_shareForestryWoodlandHCVF_tsv
- Figure5_diffOwner_site_planning_tsv
- Table1_ArealForestDemand_Avail_nmd_final_tsv
- AppFigA1_arealForestlandClaimedAvailable
- AppFigA2_landownerDistrWindpower_tsv
- App_TabA2_ArealDemand_Planning_nmd_tsv
- App_TabA3_ArealDemand_ForestryWoodlandHCVF_tsv
- App_TabA4_Areal_Owner_forestryland_tsv
- App_TabA5_summary_nmd_owner_ecoregion_tsv

Data sets

The names of the data files are systematically built and encode the content of the data sets. Inter: Intersection as derived by the 'tabulate area'-function in ArcMap

- *Site*: Intersection of the wind site polygons with underlying maps
- *3times*: Intersection of the polygons three times the wind sites with underlying maps
- *CountyMountain*: Intersection of the polygons describing the counties with delimited according to the mountain forest border
- *nmd*: Swedish national land cover map
- *owner*: Landowner categories
- *prod*: forest productivity
- *hcvf*: forest of high conservation value
- *rcl*: reclassified

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List of data files

Vindkraftverk_export_20220127a.xlsx

Information on wind turbines distributed in Sweden, accessed via the open-access platform 'Vindkollen', accessed 27 January 2022, https://ext-webbgis.lansstyrelsen.se/vbk/.

7 columns, 26686 rows

Verk_ID: Individual turbine ID

Områdes_ID: ID of the wind park

Status: status of the wind turbine; avslag (rejection), beviljat (approved), handläggs (processed/pending), uppfört (established), inte aktuellt eller återkallat (not applicable or revoked), överklagat (appealed), uppgift saknas (information missing), nedmonterat (dismantled)

Placering: Indicates whether the turbine is located on land (land), in water (vatten) or information is missing (NA)

N_Koordinat: y-coordinate according to SWEREF99 TM

E_Koordinat: x-coordinate according to SWEREF99 TM

Uppfort: Date of construction of the wind turbine (1900-01-01 means that the date has not been identified)

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Suggested_Regional_Development_2010518a.tsv

Information on regional wind energy development demand in Sweden as defined in the National Wind Energy Strategy (ER 2021, see Table 2, page22). Data used to define the regional development demand.

5 columns, 21 rows

LAN_KOD: numeric code for each county, as number

LAN_ID: numeric code for each county, as text

direct_km2: Estimated areal (km2) demand of the suggested number of turbines per county

indirect_ km2: Areal (km2) estimated as the demanded space surrounding turbines, three-times the areal of the turbines (e.g., due to associated infrastructure), per county

LAN_name: County names without Swedish special letters

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AppendixTableA1_20210518a.tsv

Information on regional wind energy development demand in Sweden as defined in the National Wind Energy Strategy (ER 2021, see Table 2, page22). Data used to define the regional development demand. Data connected to Appendix Table A1.

9 columns, 21 rows

LAN_name: County names without Swedish special letters

LAN_KOD: numeric code for each county, as text

Distribution_TWh: Suggest TWh per county

Nr_turbines: Suggested number of wind turbines per county

direct_km2: Estimated areal (km2) demand of the suggested number of turbines per county

indirect_ km2: Areal (km2) estimated as the demanded space surrounding turbines (e.g., infrastructure), three-times the areal of the turbines, per county

Total_Terrestrial_km2: Terrestrial areal (km2) of the county

direct_percentage: Percentage demanded areal by the suggested number of turbines given the terrestrial areal per county, (direct_km2/ Total_Terrestrial_km2)*100

indirect_percentage: Percentage demanded areal by the surrounding space affected by turbines given the terrestrial areal per county, (indirect_km2/ Total_Terrestrial_km2)*100

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Inter_CountyMountain_owner.tsv

Pixel numbers (10x10m) on landowner categories per county, derived by the ‘tabulate area’-function in ArcMap. Data connected to Appendix Table A5

6 columns, 25 rows

OBJECTID: row ID

CATT: numeric code for the county, including identification of the mountain area within the northern counties (CATT >100)

VALUE_1: state-owned terrestrial land

VAlUE_2: company-owned terrestrial land

VALUE_3: private-owned terrestrial land

VALUE_100: water

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Inter_site_owner_prod.tsv

Pixel numbers (10x10m) on landowner categories in the wind site area (=direct_km2) per county, derived by the ‘tabulate area’-function in ArcMap

14 columns, 24 rows

OBJECTID: row ID

CATT: numeric code for the county, including identification of the mountain area within the northern counties (CATT >100)

VALUE_0: no forest

VALUE_1: productive forest

VALUE_2: non-productive forest (woodland)

VALUE_1000: state-owned non forest

VALUE_1001: state-owned productive forest

VALUE_1002: state-owned non-productive forest (woodland)

VALUE_2000: company-owned non forest

VALUE_2001: company-owned productive forest

VALUE_2002: company-owned non-productive forest (woodland)

VALUE_3000: NIPF-owned non forest (private owned)

VALUE_3001: NIPF-owned productive forest (private owned)

VALUE_3002: NIPF-owned non-productive forest (private owned) (woodland)

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Inter_3times_owner_prod.tsv

Pixel numbers (10x10m) on landowner categories in the planning area (=indirect_km2) per county, derived by the ‘tabulate area’-function in ArcMap.

14 columns, 24 rows

OBJECTID: row ID

CATT: numeric code for the county, including identification of the mountain area within the northern counties (CATT >100)

VALUE_0: no forest

VALUE_1: productive forest

VALUE_2: non-productive forest (woodland)

VALUE_1000: state-owned non forest

VALUE_1001: state-owned productive forest

VALUE_1002: state-owned non-productive forest (woodland)

VALUE_2000: company-owned non forest

VALUE_2001: company-owned productive forest

VALUE_2002: company-owned non-productive forest (woodland)

VALUE_3000: NIPF-owned non forest (private owned)

VALUE_3001: NIPF-owned productive forest (private owned)

VALUE_3002: NIPF-owned non-productive forest (private owned) (woodland)

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Inter_CountyMountain_owner_prod.tsv

Pixel numbers (10x10m) on landowner categories on the terrestrial land of the county, derived by the 'tabulate area'-function in ArcMap.

14 columns, 25 rows

OBJECTID: row ID

CATT: numeric code for the county, including identification of the mountain area within the northern counties (CATT >100)

VALUE_0: no forest

VALUE_1: productive forest

VALUE_2: non-productive forest (woodland)

VALUE_1000: state-owned non forest

VALUE_1001: state-owned productive forest

VALUE_1002: state-owned non-productive forest (woodland)

VALUE_2000: company-owned non forest

VALUE_2001: company-owned productive forest

VALUE_2002: company-owned non-productive forest (woodland)

VALUE_3000: NIPF-owned non forest (private owned)

VALUE_3001: NIPF-owned productive forest (private owned)

VALUE_3002: NIPF-owned non-productive forest (private owned) (woodland)

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Inter_site_nmd.tsv

Pixel numbers (10x10m) of land cover types in the wind site area (=ytanspråk_km2, direct_km2) per county, derived by the 'tabulate area'-function in ArcMap.

More detailed definition of the land cover types and their coding is provided in the following document (Table 2):
https://geodata.naturvardsverket.se/nedladdning/marktacke/NMD2018/NMD2018_ProductDescription_ENG.pdf

27 columns, 24 rows

OBJECTID: row ID

CATT: numeric code for the county, including identification of the mountain area within the northern counties (CATT >100)

VALUE_111+VALUE_112+VALUE_113+VALUE_114+VALUE_115+VALUE_116+VALUE_117+VALUE_118+VALUE_121+VALUE_122+VALUE_123+VALUE_124+VALUE_125+VALUE_126+VALUE_127+VALUE_128: Forest

VALUE_2: Wetland

VALUE_3: Arable land

VALUE_41+VALUE_42: Open area

VALUE_51+VALUE_52+VALUE_53: Artifical, human-affected area

VALUE_61: Inland water

VALUE_62: Marine water

VALUE_0: No data values

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Inter_3times_nmd.tsv

Pixel numbers (10x10m) of land cover types in the planning area (=planeringsyta_km2, indirect_km2) per county, derived by the 'tabulate area'-function in ArcMap.

Detailed definition of the land cover types and their coding is provided in the following document (Table 2):
https://geodata.naturvardsverket.se/nedladdning/marktacke/NMD2018/NMD2018_ProductDescription_ENG.pdf

28 columns, 24 rows

OBJECTID: row ID

CATT: numeric code for the county, including identification of the mountain area within the northern counties (CATT >100)

VALUE_111+VALUE_112+VALUE_113+VALUE_114+VALUE_115+VALUE_116+VALUE_117+VALUE_118+VALUE_121+VALUE_122+VALUE_123+VALUE_124+VALUE_125+VALUE_126+VALUE_127+VALUE_128: Forest

VALUE_2: Wetland

VALUE_3: Arable land

VALUE_41+VALUE_42: Open area

VALUE_51+VALUE_52+VALUE_53: Artifical, human-affected area

VALUE_61: Inland water

VALUE_62: Marine water

VALUE_0: No data values

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Inter_CountyMountain_nmd.tsv

Pixel numbers (10x10m) of land cover types on the terrestrial land of the county, derived by the 'tabulate area'-function in ArcMap. Data connected to Appendix Table A5 and to define availability

Detailed definition of the land cover types and their coding is provided in the following document (Table 2):
https://geodata.naturvardsverket.se/nedladdning/marktacke/NMD2018/NMD2018_ProductDescription_ENG.pdf

28 columns, 25 rows

OBJECTID: row ID

CATT: numeric code for the county, including identification of the mountain area within the northern counties (CATT >100)

VALUE_111+VALUE_112+VALUE_113+VALUE_114+VALUE_115+VALUE_116+VALUE_117+VALUE_118+VALUE_121+VALUE_122+VALUE_123+VALUE_124+VALUE_125+VALUE_126+VALUE_127+VALUE_128: Forest

VALUE_2: Wetland

VALUE_3: Arable land

VALUE_41+VALUE_42: Open area

VALUE_51+VALUE_52+VALUE_53: Artifical, human-affected area

VALUE_61: Inland water

VALUE_62: Marine water

VALUE_0: No data values

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Inter_site_hcvf_nmd_owner_prod_rcl.tsv

Pixel numbers (10x10m) on landowner categories, productive, non-productive, and protected and non-protected forests of high conservation value (HCVF) in the wind site area (=ytanspråk_km2, direct_km2) per county, derived by the 'tabulate area'-function in ArcMap.

41 columns, 24 rows

OBJECTID: row ID

CATT: numeric code for the county, including identification of the mountain area within the northern counties (CATT >100)

VALUE_2: Forest

VALUE_1: non-forest area

VALUE_1002: state-owned forest

VALUE_1001: state-owned non-forest area

VALUE_2002: company-owned forest

VALUE_2001: company-owned non-forest area

VALUE_3002: NIPF-owned forest

VALUE_3001: NIPF-owned non-forest area

VALUE_10002: non-protected forest of high conservation value

VALUE_10001: non-protected non-forest area of high conservation value

VALUE_11002: state-owned non-protected forest of high conservation value

VALUE_11001: state-owned non-protected non-forest area of high conservation value

VALUE_12002: company-owned non-protected forest of high conservation value

VALUE_12001: company-owned non-protected non-forest area of high conservation value

VALUE_13002: NIPF-owned non-protected forest of high conservation value

VALUE_13001: NIPF-owned non-protected non-forest area of high conservation value

VALUE_20002: protected forest of high conservation value

VALUE_20001: protected non-forest area of high conservation value

VALUE_21002: state-owned protected forest of high conservation value

VALUE_21001: state-owned protected non-forest area of high conservation value

VALUE_22002: company-owned protected forest of high conservation value

VALUE_22001: company-owned protected non-forest area of high conservation value

VALUE_23002: NIPF-owned protected forest of high conservation value

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VALUE_23001: NIPF-owned protected non-forest area of high conservation value

VALUE_100002: productive forest

VALUE_100001: productive non-forest area

VALUE_101002: state-owned productive forest

VALUE_101001: state-owned non-forest area

VALUE_102002: company-owned productive forest

VALUE_102001: company-owned non-forest area

VALUE_103002: NIPF-owned productive forest

VALUE_103001: NIPF-owned non-forest area

VALUE_110002: non-protected productive forest of high conservation value

VALUE_111002: state-owned non-protected productive forest of high conservation value

VALUE_111001: state-owned non-protected non-forest area of high conservation value

VALUE_112002: company-owned non-protected productive forest of high conservation value

VALUE_112001: company-owned non-protected non-forest area of high conservation value

VALUE_113002: NIPF-owned non-protected productive forest of high conservation value

VALUE_113001: NIPF-owned non-protected non-forest area of high conservation value

VALUE_120002: protected productive forest of high conservation value

VALUE_121002: state-owned protected productive forest of high conservation value

VALUE_121001: state-owned protected non-forest area of high conservation value

VALUE_122002: company-owned protected productive forest of high conservation value

VALUE_122001: company-owned protected non-forest area of high conservation value

VALUE_123002: NIPF-owned protected productive forest of high conservation value

VALUE_123001: NIPF-owned protected non-forest area of high conservation value

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Inter_3times_hcvf_nmd_owner_prod_rcl.tsv

Pixel numbers (10x10m) on landowner categories, productive, non-productive, and protected and non-protected forests of high conservation value (HCVF) in the planning area (=planeringsyta_km2, indirect_km2) per county, derived by the 'tabulate area'-function in ArcMap.

44 columns, 24 rows

OBJECTID: row ID

CATT: numeric code for the county, including identification of the mountain area within the northern counties (CATT >100)

VALUE_2: Forest

VALUE_1: non-forest area

VALUE_1002: state-owned forest

VALUE_1001: state-owned non-forest area

VALUE_2002: company-owned forest

VALUE_2001: company-owned non-forest area

VALUE_3002: NIPF-owned forest

VALUE_3001: NIPF-owned non-forest area

VALUE_10002: non-protected forest of high conservation value

VALUE_10001: non-protected non-forest area of high conservation value

VALUE_11002: state-owned non-protected forest of high conservation value

VALUE_11001: state-owned non-protected non-forest area of high conservation value

VALUE_12002: company-owned non-protected forest of high conservation value

VALUE_12001: company-owned non-protected non-forest area of high conservation value

VALUE_13002: NIPF-owned non-protected forest of high conservation value

VALUE_13001: NIPF-owned non-protected non-forest area of high conservation value

VALUE_20002: protected forest of high conservation value

VALUE_20001: protected non-forest area of high conservation value

VALUE_21002: state-owned protected forest of high conservation value

VALUE_21001: state-owned protected non-forest area of high conservation value

VALUE_22002: company-owned protected forest of high conservation value

VALUE_22001: company-owned protected non-forest area of high conservation value

VALUE_23002: NIPF-owned protected forest of high conservation value

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VALUE_23001: NIPF-owned protected non-forest area of high conservation value

VALUE_100002: productive forest

VALUE_100001: productive non-forest area

VALUE_101002: state-owned productive forest

VALUE_101001: state-owned non-forest area

VALUE_102002: company-owned productive forest

VALUE_102001: company-owned non-forest area

VALUE_103002: NIPF-owned productive forest

VALUE_103001: NIPF-owned non-forest area

VALUE_110002: non-protected productive forest of high conservation value

VALUE_111002: state-owned non-protected productive forest of high conservation value

VALUE_111001: state-owned non-protected non-forest area of high conservation value

VALUE_112002: company-owned non-protected productive forest of high conservation value

VALUE_112001: company-owned non-protected non-forest area of high conservation value

VALUE_113002: NIPF-owned non-protected productive forest of high conservation value

VALUE_113001: NIPF-owned non-protected non-forest area of high conservation value

VALUE_120002: protected productive forest of high conservation value

VALUE_121002: state-owned protected productive forest of high conservation value

VALUE_121001: state-owned protected non-forest area of high conservation value

VALUE_122002: company-owned protected productive forest of high conservation value

VALUE_122001: company-owned protected non-forest area of high conservation value

VALUE_123002: NIPF-owned protected productive forest of high conservation value

VALUE_123001: NIPF-owned protected non-forest area of high conservation value

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Inter_CountyMountain_hcvf_nmd_owner_prod_rcl.tsv

Pixel numbers (10x10m) on landowner categories, productive, non-productive, and protected and non-protected forests of high conservation value (HCVF) on the terrestrial land in the county, derived by the 'tabulate area'-function in ArcMap.

57 columns, 25 rows

OBJECTID: row ID

CATT: numeric code for the county, including identification of the mountain area within the northern counties (CATT >100)

VALUE_2: Forest

VALUE_1: non-forest area

VALUE_1002: state-owned forest

VALUE_1001: state-owned non-forest area

VALUE_2002: company-owned forest

VALUE_2001: company-owned non-forest area

VALUE_3002: NIPF-owned forest

VALUE_3001: NIPF-owned non-forest area

VALUE_10002: non-protected forest of high conservation value

VALUE_10001: non-protected non-forest area of high conservation value

VALUE_11002: state-owned non-protected forest of high conservation value

VALUE_11001: state-owned non-protected non-forest area of high conservation value

VALUE_12002: company-owned non-protected forest of high conservation value

VALUE_12001: company-owned non-protected non-forest area of high conservation value

VALUE_13002: NIPF-owned non-protected forest of high conservation value

VALUE_13001: NIPF-owned non-protected non-forest area of high conservation value

VALUE_20002: protected forest of high conservation value

VALUE_20001: protected non-forest area of high conservation value

VALUE_21002: state-owned protected forest of high conservation value

VALUE_21001: state-owned protected non-forest area of high conservation value

VALUE_22002: company-owned protected forest of high conservation value

VALUE_22001: company-owned protected non-forest area of high conservation value

VALUE_23002: NIPF-owned protected forest of high conservation value

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VALUE_23001: NIPF-owned protected non-forest area of high conservation value

VALUE_100002: productive forest

VALUE_100001: productive non-forest area

VALUE_101002: state-owned productive forest

VALUE_101001: state-owned non-forest area

VALUE_102002: company-owned productive forest

VALUE_102001: company-owned non-forest area

VALUE_103002: NIPF-owned productive forest

VALUE_103001: NIPF-owned non-forest area

VALUE_110002: non-protected productive forest of high conservation value

VALUE_111002: state-owned non-protected productive forest of high conservation value

VALUE_111001: state-owned non-protected non-forest area of high conservation value

VALUE_112002: company-owned non-protected productive forest of high conservation value

VALUE_112001: company-owned non-protected non-forest area of high conservation value

VALUE_113002: NIPF-owned non-protected productive forest of high conservation value

VALUE_113001: NIPF-owned non-protected non-forest area of high conservation value

VALUE_120002: protected productive forest of high conservation value

VALUE_121002: state-owned protected productive forest of high conservation value

VALUE_121001: state-owned protected non-forest area of high conservation value

VALUE_122002: company-owned protected productive forest of high conservation value

VALUE_122001: company-owned protected non-forest area of high conservation value

VALUE_123002: NIPF-owned protected productive forest of high conservation value

VALUE_123001: NIPF-owned protected non-forest area of high conservation value

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Data_AppFigA1.xlsx

Information on county size (kHa) and demanded areal (kHa) of the regional suggested planning area on productive forest land per county following the National Wind Strategy (ER 2021, see Table 2, page 22). Data used to define the regional development demand.

4 columns, 21 rows

zon_IDD: ecoregion

CATT2: county

kha_county: terrestrial areal per county (kHa)

kha_plan: areal of planning areal per county (kHa)