Landscape history and land use in SW Norway

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The Norwegian Institute for Nature Research (NINA) is an independent, not-for-profit institute working in the areas of fish and game management, monitoring, biodiversity, ecosystems services, sustainability, and community development of natural resource management.

**NINA’s key statistics for 2014**

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**Number of employees (full-time equivalents) 2014**

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<td>- scientific staff</td>
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**NINA’s turnover 2014**

- Research projects, national and international funding: 23.4%
- Block grant, Ministry of Environment and The Research Council of Norway: 12.6%
- Commissioned projects private and industry: 13.1%
- Commissioned projects, management authorities: 51%

Total turnover: 36.7 mill. EUR
An efficient multivariate approach for estimating preference when individual observations are dependent

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Summary

1. We discuss aspects of resource selection based on observing a given vector of resource variables for different individuals at discrete time steps. A new technique for estimating preference of habitat characteristics, applicable when there are multiple individual observations, is proposed.
2. We first show how to estimate preference on the population and individual level when only a single site- or resource component is observed. A variance component model based on normal scores in used to estimate mean preference for the population as well as the heterogeneity among individuals defined by the intra-class correlation.
3. Next, a general technique is proposed for time series of observations of a vector with several components, correcting for the effect of correlations between these. The preference of each single component is analyzed under the assumption of arbitrarily complex selection of the other components. This approach is based on the theory for conditional distributions in the multi-normal model.
4. The method is demonstrated using a data set of radio-tagged dispersing juvenile goshawks and their site characteristics, and can be used as a general tool in resource or habitat selection analysis.

Key-words: conditional expectations, correlation analysis, estimation, goshawk, intraclass correlation, multivariate normal distribution, preference
Geographical Definitions

South-west Norway

South-west Norway Statistical Region

More & Romsdal
Sogn & Fjordane
Hordaland
Rogaland

Vest-Agder
Aust-Agder

Area: 33318 sq. km

Lat. Hermaness >
Lat. Lerwick >
Lat. Fair Isle >
Lat. Thurso >

Latitude of Harris, Ullapool, >
Dornoch

West Norway

West Norway Statistical Region

More & Romsdal
Sogn & Fjordane
Hordaland
Rogaland

Area: 58582 sq km

(Highland Region, Western Isles & Argyll and Bute: 35639 sq. km)

(Area of Scotland N & W of Firths of Tay and Clyde: 56301 sq km)
Oslibakken, Rogaland 1911
Old peat digging with pine roots, west Norway, 1917
Industrial scale peat production on Fedje island near Bergen, 1903. The peat was transported to the quayside by train. This was the main source of domestic and industrial fuel in Bergen in the later 19th and early 20th centuries.
Age of final establishment of moorland, or grassland/permanent infields, in coastal SW Norway

Peat was the main source of domestic fuel in coastal Norway for many centuries.

This was due to the lack of wood in the region; in coastal areas, conversion to open moorland was «substantially complete by the Bronze Age».

Further deforestation and moorland establishment continued inland in SW Norway to the Viking era and beyond. Moorland reached its maximum extent in the 19th century.

This open landscape was «anthropogenic in origin», due primarily to the effects of grazing and associated activities such as muirburn and use for firewood (Prøsch-Danielsen & Simonsen 2000. Veget. Hist. Archaeobot. 9:189-204).

Peat cuttings and drying stacks in Jæren (coastal plain near Stavanger). Kitty Kielland, oil on canvas, 1900.
Climate comparisons

(map to scale and in correct relative positions)

www.nina.no
Mean Annual Windspeeds

Baltasound 6.9 m/s >
Lerwick (S. Screen) 7.5 m/s >
Fair Isle 7.4 m/s >
Kirkwall 6.9 m/s >
Stornoway 5.1 m/s >
S. Uist (Range) 7.1 m/s >
Barra airport 7.5 m/s >
Tirree 7.3 m/s >
Islay airport 6.4 m/s >
Campbeltown airport 6.2 m/s >
Røvær 6.8 m/s >
Utsire 8.2 m/s >
Kvitsøy 6.5 m/s >
Eigerøya 8.0 m/s >
Lindenes 7.8 m/s >

Sources: Meteorological Office
Meteorologisk institutt
Geology

Source: Norges geologiske undersøkelse
Land cover history, climate, and geology: Summary

• SW Norway has (as Scotland) been largely deforested for centuries; in coastal districts, for millennia.
• Research indicates this was caused by the cumulative effects of livestock grazing and associated land uses, such as muirburn and felling for timber and fuel.
• Data on climate is comprehensive, standardised, publically available, and consists of precisely quantifiable physical measurements collected by the respective Met Offices.
• It indicates that the climates of SW Norway and Highland Scotland are very similar: highly oceanic, mild, and wet; precipitation varying strongly depending on topography and rain shadow effects; and with similar seasonal temperature ranges.
• Winds as measured at the west coast are overall slightly stronger in SW Norway. Some parts of SW Norway are wetter than anywhere in Scotland.
• The geology of the two areas is also very similar. Hard, volcanic or metamorphic rocks, largely from the same mountain building episodes, predominate. Soils are generally infertile.
Fidjadalen 1927

http://jarenfri.no/no/steder/friluftsgarden-man/

Fidjadalen 2007
Note woodland regrowth (1960, 2004) on bare rock slope, upper right of 1885 image.
Kvenadhøla was one of many sawmills in inland SW Norway that sawed lumber using water power for the ‘skotethandel’, or ‘Scottish Trade’ – i.e. for export - in the later 17th to 19th centuries.

The trade took its name from the dominance of Scotland as a destination for the timber, and lead to further substantial declines in the remaining forests of inland SW Norway.
Oslibakken near Stavanger, 1911

X = approximate point of shot 1911 photograph

Oslibakken near Stavanger, 2015

Photo: Erlend Tøssebro
Future trends in land cover

**Adapted from:**

Forest defined as trees >2.5m high. "Other land cover types" mainly infiel farmland and urban.

Input baseline maps: cover as mapped in 2007.

- Potential natural forest regeneration
- Actual forest cover (2007)
- Jæren (mainly arable and infiel pasture)
- Montane scrub and alpine
- Other land cover types

* Montane scrub/alpine and Jæren split from "other land cover" category

NB Assuming current land use patterns and trends do not change significantly. Much of the ‘potential natural forest regeneration’ mapped is occurring now, but has not reached the >2.5m height threshold. Regeneration is due to reductions in grazing pressure and associated land uses (muirburn, firewood collection). In recent years climate change may be marginally affecting the altitude limits of zones, but if so is subordinate to browsing effects (Bryn (2008) Norw. J. Geog. 62:251-270; Hofgaard et al (2010) Plant Ecol. & Diversity 3:19–27).
Woodland expansion: area

- The total area of forest classified as ‘productive’ increased in SW Norway by 55% 1963-93 (Source: Norwegian Forest & Landscape Institute).
- ‘Productive’ is a forestry statistics term. It means potential increase in harvestable timber volume of >1m³/ha/year, whether or not harvested for timber.
- Between forest inventory periods 2005-09 and 2010-14 the annualised increase in area of woodland in West Norway was 305 sq. km/year, or 2.6% of the land area over 5 years. (Data: Statistisk sentralbyrå)
- Almost all of the expansion in area in the period 2005-2014 has been through natural regeneration.
- Scottish Forestry Strategy (2006) for increased forest area: 17% to 25% of land cover (+8% increase) by 2030; 1000 km² increase by 2022.
Annualised increase in standing timber volume 1996-2010: 3,943,800 cubic metres / year

Using volume increase ratio 1996-2010 spruce:pine:deciduous (mainly birch) and Forestry Commision conversion factors, this represents an annual sequestration of 0.99MtC.

Notional value, EU CO2 emissions auction price 16/11/15 (€8.46/tonne CO2): €26.6 million/year

Does not include bark, branches, leaves, root system, or soil carbon.

Scottish Forest Strategy sequestration target: sequester 1.0MtC annually by 2020 through woodland expansion.
Recent regeneration on wet peat
<Old peat digging in regenerating birch, cleared for archaeological investigation
6% of Norway is blanket bog. Tree growth on drier areas is ubiquitous.
Summary: Recent landscape history

- Landscape history in SW Norway was similar to Scotland from the arrival of agriculture (Neolithic period) until the end of the period when land use was dominated by subsistence pastoralism and associated land uses (Norway: late 19th century; Scotland 17th-18th century).
- Since when landscape histories have diverged sharply.
- SW Norway has been reforesting, in part through forestry practices but mainly through natural regeneration, from the later 19th century and especially since the 1950s. In recent decades reforestation by natural means has been very rapid.
- Research* has determined that this widespread natural regeneration has been due to reductions in grazing pressures and associated land uses such as muirburn and fuelwood collection.
- This was caused by mass (voluntary) emigration to N. America in the period 1862-1914; and by changes in social and economic conditions from the 1950s.
- 90% of the coastal region moorland of the 19th century is now either reclaimed arable/improved pasture or (mainly) woodland (Source: [Norwegian Environment Agency](https://wwwMiljøverndepartementet.no)).
- Much of the natural regeneration has occurred on wet peat soils.
- Most new woodland is of an open structure with an understory remaining suitable for purposes such as livestock grazing at moderate densities. Most is so used.

1. Gården Li & Hidrasundet
Annual precipitation

Weather data from www.senorge.no
Days/year snow >25cm deep

Mean January temperatures

Mean July temperatures
Geology

M-Gb,Gn,A - Mangerite to gabbro, gneiss & amphibolite
C-A - Charnockite to anorthosite, partly metamorphosed
A++ - Amphibolite, hornblende-gneiss, mica gneiss
Ag,G,fG - Augen gneiss, granite, foliated granite
Extreme wind events at Eigerøya weather station, 30km NW, 1994-2015 (Force 10, 25-28m/s, is annual):

- 08.12.1994 Force 11 (29-32m/s)
- 19.01.1995 Force 11
- 30.01.1995 Force 11
- 17.02.1997 Force 11
- 28.11.1999 Force 11
- 11.01.2005 Force 12 (>33m/s)
- 13.01.2007 Force 11
- 10.08.2014 Force 11
- 10.01.2015 Force 12 (>33m/s; max gust 45.6m/s)
Drystane farm ruin, Hidrasundet

Photo: Thomas MacDonell
<Våskeland: Old hill farm

Røynes: Old hill farm

http://www.kvinesdal.no/farmregister

Tjellås: Old hill farm

Elevation 352m asl
2. Mån & Fidjadalen
Average annual precipitation, Fidjadalen

Average annual number of days with snow depths >25cm, Fidjadalen

NB very large interannual variation in average snow cover duration, due to the combination of very high precipitation and near-zero average winter temperatures in area.
“Peat they took among other places from Månemyra. Peder relates that they found the roots of large trees up there”

-1987 oral history account by Peder Østebø, who lived at Mån until 1914.
‘Almost exactly 1000’ sheep are turned out to graze in Fidjadalen each summer. They graze in the glen itself and in the surrounding hills. (Source: farmer at Eikeskogen below Fidjadalen, in conversation with the author)
Birch and aspen colonising open scree
3. Sagvatnet, Bømlo
Woodland at Sagvatnet is predominantly Scots Pine.

Satellite images: [www.norgeskart.no](http://www.norgeskart.no)
All trees at Sagvatnet are less than 150 years old. Most are under 100 years old. All are naturally regenerated. Previously coastal moor from Bronze Age until decline in grazing pressure associated with mass (voluntary) emigration in the later 19th and early 20th centuries.

Wind-bent aspen stand at Sagvatnet

Extreme wind events at Røvær weather station 25km SSW, 1994-2015 (Force 10, 25-28m/s, is annual):

08.12.1994 Force 11 (29-32m/s)
19.01.1995 Force 11
30.01.1995 Force 11
17.02.1997 Force 11
28.11.1999 Force 11
11.01.2005 Force 11
13.01.2007 Force 11
10.08.2014 Force 11
10.01.2015 Force 12 (>33m/s)
4. Natural treeline zonation: an example from Byklehaise

- Heights of zone transitions are sensitive to climate. They decline towards the coast and tend to be lower on north facing slopes.
- Nearer the coast there is little willow in the ‘willow region’, due to less protection from snow cover.
- But there is always a zone of increasingly dwarfed open woodland above the timberline and below the alpine zone.

Climate & geology are closely similar to the central Cairngorms.
Pine-birch belt transition, Bykleheiane
Birch belt on Hovdenut

Hartevatnet 759 m
On ridges, etc. where snow normally blows off in winter, dwarfed birches usually predominate. Willow is typically found in more sheltered locations with snow lie.
Willow zone c. 950m

(Typical ‘willow zone’ vegetation. The term means the zone where montane willows are common; not that the zone is all willow, or even dominated by willows. Birch, rowan, juniper and aspen are typically common as well; with krummhölz pine in some places.

This area was open moor 50 years ago; regeneration has followed decline in grazing pressures. Cows and sheep are still grazed at this site in summer at moderate densities; wild browsers include moose and reindeer)
‘Landbruk’ – Land use

• ‘Landbruk’ (pron. ‘landbrook’) is a central concept in understanding how land is used in Norway.

• ‘Landbruk’ literally translates as ‘Land Use’

• But is usually translated into English as ‘farming’ or ‘agriculture’. This can be misleading.

• ‘Landbruk’ is a wider concept. It means making a living from the land, most usually from diverse sources.

• Usually several income generating activities are carried out on any given piece of land, by the same owner/occupier landowner. Monocultural use is rare, except on arable fields.
‘Land Use’ (farming, forestry, hunting etc) properties per 5km grid square

- 12 or fewer (<0.5/sq km)
- 13-25 (0.5-1/sq km)
- 26-75 (1-3/sq km)
- 76 or more (>3/sq km)

Grey: state owned, state common lands (‘Statsallmenning’), etc. (mainly high mountain plateaus above the natural treeline)

Source: Statistics Norway (www.ssb.no)
Number of farms practising agriculture, and average area of arable and improved pasture per farm, Norway, 1969-2011

Source: Farming statistics, Statistisk sentralbyrå
Land use properties with different combinations of farmland and woodland, SW Norway (Vest Agder, Rogaland, Hordaland), 2010

- **Farmland only**: 9617
- **Woodland only**: 4015
- **Farmland and woodland**: 22097

Source: Statistisk sentralbyrå
The increase in Rogaland (300km²) is due to conversion of moorland to arable and improved pasture.
Slow declines in Hordaland and Vest-Agder largely due to small outlying fields going out of production.
Average % farm owner’s income by source, Norway, 2013

6.4% of the population of SW Norway are resident on Landbruk properties.

While ownership is individual, properties are typically worked by families.

Mean gross income 2013: 568 700kr

Source: Farming statistics, Statistisk sentralbyrå

Photo: [http://www.landbruk.no/](http://www.landbruk.no/)
Woodland

http://www.nordicforestry.org/facts/Norway.asp

Ownership structure

- 119600 woodland proprietors in 2008 (Total population: 4.9 million)
- Average property 58 hectares ’productive woodland’*
- 97% of owners private individuals
- 80% of area owned by private individuals
- 20% of area owned by forestry companies, state, etc.
- Forestry employs 3900 full time equivalents in direct timber harvesting
- The wider industry (processing etc) employs 22000 full time equivalents

*definition: area with annual growth of woody mass >1m³/ha
Forest ownership in Orkdal kommune, Norway

- Individuals resident in Orkdal kommune: 78%
- Companies: 2%
- Government bodies: 5%
- Non-resident individuals: 6%
- Songli research station (mostly nature reserve): 9%

Data by area.
Source: Orkdal kommune
Forestry cooperatives

- Most forest owners belong to regionally-based forestry cooperatives
- These do the bulk of timber management, harvesting and sales
- This allows for investment in modern machinery and other economies of scale
- Woodland is exploited for other purposes (hunting, grazing, recreational sales, etc.) by the landowner individually
Non-timber sources of income from woodland, Norway, 2007

Data for all Norway.
Does not include grazing of domestic stock.

- Sale of hunting & fishing rights: 21%
- Management for hunting & fishing: 3%
- Cabin rental: 17%
- Sale of cabin plots: 20%
- Further processing of wood for sale: 7%
- Christmas trees: 4%
- Other income (including fuelwood): 27%

Source: Statistisk sentralbyrå
Population densities (residents/km²), Highland Region and SW Norway
Population densities (residents/km$^2$) Highland Region and SW Norway, excluding main urban settlements

Inverness, Kristiansand, Stavanger (including Sola kommune), Bergen excluded
SW Norway is closely similar in the basic conditions of life (climate, landforms, geology) to Highland Scotland, as comprehensive data demonstrates. It was formerly strongly deforested; in coastal regions almost completely so since at least the Bronze Age. It has reforested, largely through natural regeneration, since the late 19th century, and especially since the 1950s. Research demonstrates that this been a result of reductions in grazing intensities and associated land uses (e.g. muirburn, fuelwood).

Natural reforestation is continuing at a rapid rate. Much of this regeneration is occurring on wet peat soils formed during the deforested period. Including on hard, infertile rock types in very wet, mild, and windy ocean-edge locations. It was and is a working cultural landscape. Land use is diversified, typically with multiple income streams from the same property; including agriculture, grazing, forestry, hunting and fishing sales, fuelwood production, cabin sales and rental. Most land is privately owned; owner-occupation is typical and strongly encouraged by government policy. Landbruk properties are much smaller than the typical holding in Scotland. Most are an element in a wider family income. The overall population density on the land is higher than in Highland Scotland.
Forestry

Much woodland is in clear-fell rotation for timber (as primary use)
Much is in mixed-use for timber, firewood, grazing, hunting, and forest products.
Trees in this form of management are felled in small cuts, or selected individually ("plukkehøgst"). This results in a more varied woodland structure.
Grazing

Population of sheep, SW Norway (summer): c. 450 000  Source: Statistisk sentralbyrå
A hunting culture

• There were 473 100 registered hunters in Norway in 2014; 9.5% of the total population.
• 201 400 people paid the annual hunting licence fee (which pays for the game management system).
• Of whom 199 300 were Norwegian; 9% of adult males paid the fee.
• The game resource is a public asset (as in Scotland).
• Hunting rights are owned by the landowner (as in Scotland).
• Management is through a **publicly accountable system**, in which government, communities, landowners, and hunters have clearly defined roles.
• Red and roe deer, and grouse, are the main game species in SW Norway.
Carcass weights, body condition, and calving % all started to decline in recent years, due to incipient competition for food. This indicated populations had risen to a point beyond the optimal for harvest purposes, and an animal welfare issue.

Reasons for managed reductions

- Reducing road accident risks.
- Reducing negative impacts on forestry and agriculture.

Decline from 2010-11 hunting season is due to managed population reduction.

Dressed carcass weights of red deer in Norway and Scotland, 2008-15

- Carcass with head, lower limbs, internal organs removed.
- In Scotland, including hide;*
- In Norway with hide removed

2 ½+ stag Norway

2 ½+ hind Norway

1 ½ year old stag Norway

1 ½ year old hind Norway

2 ½+ hind Scotland

1 ½ year old stag Scotland

1 ½ year old hind Scotland

2015 data for Norway is for season to date

Data:
Norway: National deer register (www.hjortvitregisteret.no)
Scotland: Abermethy Estate records

*Weight of 1 ½ year old Scottish hind hide, 2015: 5kg
2 ½+ hind: 6kg. Source: Deer Consultancy Services
Gathering

Berries, fungi and common flowers may be picked by anyone as part of ‘Allemannsretten’ (‘Everyman’s right’).
2009 household fuelwood consumption: 1,600,000 tonnes (9% up on 2008); or 816kg per household*

2008 declared income from fuelwood sales: 323 million kroner (£37 million)*

*Source: Statistisk sentralbyrå
Education
Most Norwegian children go to kindergarten.
All kindergartens often go on excursions into the woods.
About a third of kindergartens are “nature kindergartens”, outdoors all day in most weathers.
Excursions and longer stays (‘camp school’) in the outdoors are a required part of the curriculum throughout the period of compulsory education.
Hytter (cabins)

Number of cabins, summer houses, etc, Norway, 2009: 398 884
(1 per 12 inhabitants)
Source: Statistisk sentralbyrå
Det norske turistforening (Hiker’s Association) membership: 258 000 (5% of population)
"Oot on tour – never soor!"
(392 000 hits for exact phrase, Google)
All of the economic and social activities shown in the preceding sequence take place today in the landscapes shown. Formerly, the only significant economic activity in both landscapes was rough grazing. See also [HD video of Tysnes island](#).
Frafjord cabins. Sleeps 6, 750kr/night or £9.56/person/night

Bjåen Turisthytte, Bykleheiane. Sleeps up to 22, £15/person/night
Example of costs

• September 2015: 5-night study tour from Scotland, 15 people, to SW Norway (Stavanger- Hidrasund- Frafjord- Bykle-Stavanger) ex Aberdeen, all flights, car rental, fuel, accommodation, food (self-catering) included: £560/person.