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Variations of Yield and Utilisation of Bilberries (*Vaccinium myrtillus* L.) and Cowberries (*V. vitis-idaea* L.) in Finland

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So far, only rough estimates for the utilisation rates of wild berries in Finland have been available. One reason for this is that there has been a lack of empirical-knowledge-based studies concerning total yields of wild berries and their yield variations. This study had three aims: 1) total bilberry and cowberry yields of an average crop year were calibrated for different (abundant and poor) crop years using the inventory data on wild berries collected by the Finnish Forest Research Institute (1997–2008); 2) national utilisation rates of bilberries and cowberries were calculated for three different berry years 1997–1999; and 3) regional utilisation rates of these berry species were calculated for the year 1997. According to calculations, annual bilberry yields in Finland vary from 92 to 312 million kg. For cowberry, the range of variation in total berry yields is from 129 to 386 million kg. It was also found that approximately the same proportion of the total yield of bilberries (i.e. 5–6%) was collected between 1997 and 1999. Utilisation rates of cowberries were also quite constant varying from approximately 8% to nearly 10%. In 1997, bilberries and cowberries were utilised most intensively in the eastern parts of the country and in the Oulu-Kainuu region. The results of this present study describe the situation before the phenomenon of foreign pickers. It can be presumed that commercial wild berry picking by migrant collectors has so far affected both national and regional utilisation rates of wild berries.

Keywords bilberry, cowberry, total berry yield, yield variation, utilisation of wild berries
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1 Introduction

Picking wild berries in Finland has been a popular traditional household and recreational activity. Contrary to other Nordic countries it has maintained its popularity in Finland and shown only slight indications of declining during the last decades (Pouta et al. 2006). Nowadays approximately 60% of the Finnish population participate in berry picking every year (Saastamoinen et al. 2000, Pouta and Sievänen 2001, Pouta et al. 2006). For comparison, in 1981 the participation rate of berry picking was 69% and ten years later it was 65% (Liikkanen et al. 1993). The popularity of berry picking is based on the Nordic "everyman's right", which is the right of open access to both private and public land, including the right to pick berries and mushrooms on them (Salo 1995).

Berry picking and utilisation provide many kinds of benefits (see e.g. Kangas 2001a). Berries are picked for both household use and sale, and berry picking is also considered to be healthy exercise. As Finland is a country with a high standard of living, for the majority of people the purpose of picking is leisure or to get berries for their own use rather than subsistence or cash income. However, in sparsely populated eastern and northern parts of the country, which suffer from high unemployment, berry picking provides important additional income for the population (Saastamoinen 1996, Kangas 2001b). Thus, the relative importance of wild berries, as well as other non-wood forest products (NWFPs), is different in different parts of the country.

Despite of the continuing interest, wild berries are largely regarded as underutilised in Finland. It has been estimated that only 5–10% of the total yield of wild berries is collected every year (Raatikainen 1985, Salo 1995). Utilisation rates of the two most common berries, bilberry (*Vaccinium myrtillus* L.) and cowberry, or lingonberry (*Vaccinium vitis-idaea* L.), have been estimated at 4% and 11% respectively (Hiirsalmi and Lehmushovi 1993). All these national estimates are rough and largely hypothetical because they are not based on accurate data about the total berry yield.

In Sweden and Russia, underutilisation of large wild berry resources is an equally well-known feature. Sweden is the only country where a nationwide field inventory of wild berries has been conducted (Eriksson et al. 1979, Kardell 1980, Kardell and Carlsson 1982). At the end of the 1970s, it was found that Swedish people collect 7% of annual wild berry production for home consumption (Hultman 1983). A similar study conducted 20 years later indicated that this proportion had decreased significantly since both participation in berry picking and the volume of berries picked by each collector had decreased (Lindhagen and Hörnsten 2000). In Russian Karelia it has been estimated (in the absence of accurate data) that a maximum of 10–15% of the total yield of bilberries and cowberries is harvested annually (Belonogova 1988, Gosudarstvennyj doklad… 2001).

Several public measures aimed at increasing the utilisation of wild berries have been carried out in Finland. The most powerful of these is a traditional tax-free income of pickers (Saastamoinen 1999). In addition, during the last two decades several national and regional development programmes have been established in order to promote the natural products sector (e.g. Keräilytuotealan kehittämisohjelma… 1995, Luonnontuotealan nykytilan… 2000, Moisio 2006). For example, in the 1990s the target of the programme introduced by a working group of the Ministry of Agriculture and Forestry was to increase the utilisation of berries and mushrooms by 30% (Keräilytuotealan kehittämisohjelma… 1995). Other interventions to promote NWFP utilisation include training and research. Since 1997, the Finnish Forest Research Institute has supported wild berry picking by developing annual yield forecasts based on the dataset of a special berry and mushroom information system (see e.g. Salo 1999).

When one's aim is to increase the utilisation of wild berries, it is essential to know their total yields both at national and regional levels (see e.g. Luonnontuotealan nykytilan… 2000). In addition, as berry yields vary greatly from year to year (e.g. Wallenius 1999, Isaeva 2001, 2002), it is important to know the yields during different crop years. Recently Turtiainen et al. (2005, 2007) calculated total bilberry and cowberry yields, for the whole of Finland and 13 regional Forestry Centre areas (see Fig. 1), using the regional berry yield models of Ihalainen et al. (2005) and the results of empirical berry yield studies conducted in different parts of the country between 1976 and 2003. The yields

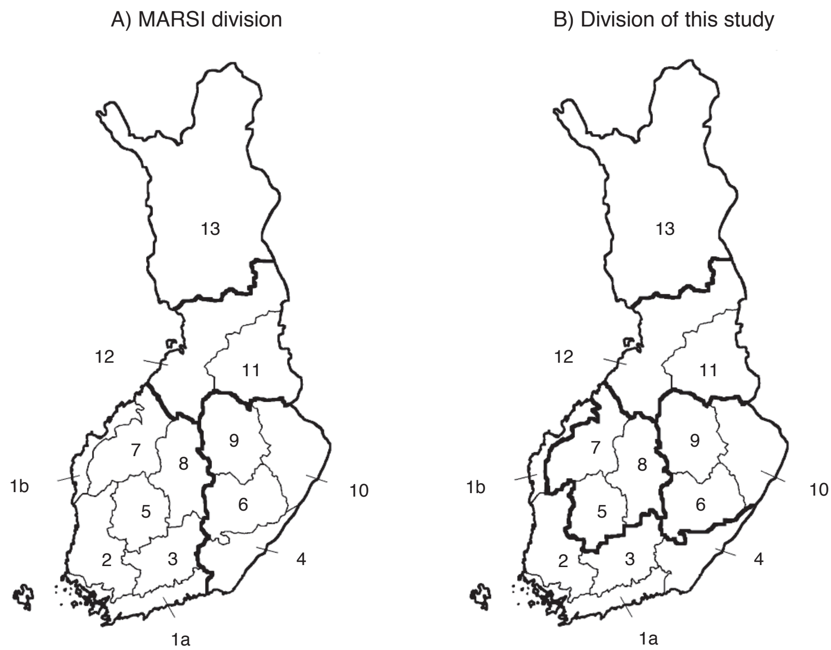

Fig. 1. Forestry Centres of Finland: 1. Coast (1a. Southern Coast, 1b. Ostrobothnia), 2. Southwest Finland, 3. Häme-Uusimaa, 4. Southeast Finland, 5. Pirkanmaa, 6. South Savo, 7. South Ostrobothnia, 8. Central Finland, 9. North Savo, 10. North Karelia, 11. Kainuu, 12. North Ostrobothnia, 13. Lapland.

A) Four regions based on MARSI division: I) western Finland (Forestry Centres 1, 2, 3, 5, 7 and 8), II) eastern Finland (4, 6, 9 and 10), III) Oulu-Kainuu (11 and 12), IV) Lapland (13).

B) Five regions based on the division of this study: I) southern Finland (1–4), II) western Finland (5, 7 and 8), III) eastern Finland (6, 9 and 10), IV) Oulu-Kainuu (11 and 12), V) Lapland (13).

were calculated for an average berry year and both mineral soil sites and peatlands were taken into account. According to the calculations, Finnish forests and peatlands could produce an average of about 184 million kg of bilberries and 257 million kg of cowberries annually (Turtiainen et al. 2007). Roughly half of the total berry yield of both berry species (i.e. 55%) is produced by three northernmost Forestry Centres (see Fig. 1). It is worth noting that the calculations of Turtiainen et al. (2005, 2007) did not take into account treeless fell areas and the birch zone of the northernmost Lapland and treeless mires. Also small forests inside urban areas are excluded.

In Finland, there are quite a few national estimates of the total berry quantities picked (see e.g. Saastamoinen et al. 2000). In 1997 and 1998 the amount of wild berries collected by Finnish households, both for own use and for sale, were studied using large-scale questionnaire surveys by Saastamoinen et al. (2000). It was found that during a good berry year, 1997, the amounts of bilberries and cowberries picked were 18.1 and 26.6 million kg respectively. In 1998, the corresponding estimates were 11.2 and 25.8 million kg respectively. The year 1998 was quite an average berry year nationally, although regional variation in berry yields was high (see Salo 1999). In both years, approximately 31–32% of the total harvest of bilberries and cowberries was collected for sale (Saastamoinen et al. 2000). The picking data was collected also for a poor berry year 1999 but only some preliminary results have so far been given.

By combining the data on collection (the years 1997 to 1999) and production (Turtiainen et al. 2005, 2007) one could easily calculate the utilisation rates of bilberries and cowberries in Finland during the last three years of the twentieth century. This, however, requires that total berry yields have to be calibrated for different (good and poor) crop years so that utilisation rates could be calculated correctly. This calibration was the first aim of this study. After that, national utilisation rates of both berry species were computed for each of the study years from 1997 to 1999. Finally, as the picking data for 1997 was the most comprehensive, it was also possible to calculate regional utilisation rates for this particular year. In this study, Finland was divided into four regions according to so-called MARSI division used to estimate berries bought by berry trade and industry (Fig. 1A) and for these regions the utilisation rates were derived. Regional utilisation rates were also estimated for five areas (Fig. 1B) that were developed for the purposes of this study.

Table 1. Number of bilberry and cowberry stands included in this study during the period from 1997 to 2008. In the parentheses, numbers of stands on medium or more fertile site types (N_{Mj}) and on rather poor or poorer site types (N_{Pj}) are presented ($j = 1997, \ldots, 2008$).

Year	Number of bilberry stands (N_{Mj}; N_{Pj})	Number of cowberry stands (N_{Mj}; N_{Pj})
1997	63 (40; 23)	56 (10; 46)
1998	158 (109; 49)	123 (17; 106)
1999	123 (91; 32)	113 (21; 92)
2000	126 (87; 39)	104 (24; 80)
2001	91 (66; 25)	80 (12; 68)
2002	81 (56; 25)	80 (13; 67)
2003	87 (62; 25)	72 (16; 56)
2004	71 (51; 20)	63 (12; 51)
2005	76 (53; 23)	58 (9; 49)
2006	58 (40; 18)	52 (10; 42)
2007	38 (27; 11)	46 (9; 37)
2008	42 (27; 15)	38 (7; 31)

2 Materials and Methods

2.1 Calibration of Total Berry Yields

In order to calibrate the total berry yields of an average berry year for different crop years the inventory data (so-called MASI data) on wild berries collected by the Joensuu Research Unit of the Finnish Forest Research Institute was used. The nationwide inventory concerning yields of the most economically important wild berries (cowberry, bilberry, cloudberry (*Rubus chamaemorus* L.)) and the most common edible mushrooms was started in 1997 and have been carried out annually since then (Salo 1999, 2005).

The national observation network was established in different parts of Finland for the MASI inventory (Salo 1999). Flowering and ripening of bilberries and cowberries are recorded in forest stands found to be good growing sites for bilberry and cowberry. The stands are different for bilberry and cowberry. In each stand, there are five permanent sample plots of 1 m^2. The number of stands has varied from year to year (e.g. Eronen 2004, Miina et al. 2009) and, in addition, ripe berries have not been inventoried in all stands. In this study, only those stands in which both ripe berries as well as flowers and unripe berries have

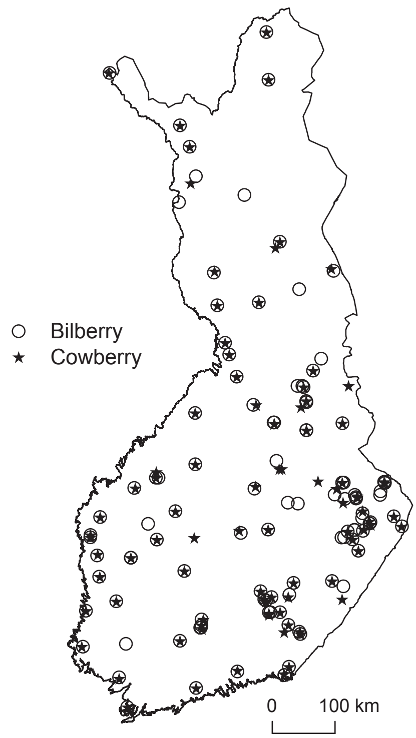

Fig. 2. Locations of bilberry and cowberry stands in the MASI inventory in 2001.

been inventoried were considered. The numbers of stands included in this study, as well as the division of stands into different site fertilities, are presented in Table 1. It is worth noting that neither bilberry nor cowberry stands cover uniformly the country. Fig. 2 presents the locations of bilberry and cowberry stands in 2001.

In this study the MASI data collected during the twelve year period (1997 to 2008), each year representing different levels of berry crops, was employed. The calibration was based on mean annual berry yields (kg ha^{-1}), which were calculated for both species separately (Fig. 3), using the following formula:

$$\bar{y}_j = \frac{(N_{Mj}\bar{x}_{Mj}w_M + N_{Pj}\bar{x}_{Pj}w_P)}{N_j} \times 10c \quad (1)$$

where

$\bar{y}_j$ = mean annual berry yield (kg ha^{-1}) in year *j* ($j = 1997, \ldots, 2008$)

N_{Mj} = number of stands on medium or more fertile site types in year *j* (see Table 1)

$\bar{x}_{Mj}$ = average number of ripe berries (berries per m^2) on stands which belonged to medium or more fertile site types in year *j*

w_M = weight of one ripe berry on medium and more fertile site types (g)

N_{Pj} = number of stands on rather poor or poorer site types in year *j* (see Table 1)

$\bar{x}_{Pj}$ = average number of ripe berries (berries per m^2) on stands which belonged to rather poor or poorer site types in year *j*

w_P = weight of one ripe berry on rather poor and poorer site types (g)

N_j = $N_{Mj} + N_{Pj}$ (i.e. number of stands in year *j*; see Table 1)

c = coverage of a species (%)

The average weights of ripe berries on medium and more fertile site types (w_M) and on rather poor and poorer site types (w_P) were determined on the basis of earlier studies (Kuchko 1988, Ihalainen et al. 2003). In the case of bilberry, they were 0.36 g and 0.32 g respectively, and in the case of cowberry, they were 0.25 g and 0.23 g respectively. Multiplier "coverage of a species" indicates the proportion of the total land area that is, according to the Finnish National Forest Inventory (NFI) in 1995, covered by a berry species in question. Vegetation surveys for NFI have been conducted on 3000 permanent sample plots which are located systematically throughout the country (Heikkinen and Reinikainen 2000, Miina et al. 2009). According to NFI, the coverage of bilberry plants is 0.08 and the corresponding figure for cowberry is 0.06 (Hotanen et al. 2000).

Total berry yield (bilberry and cowberry separately) for a certain year *j* was determined as follows:

$$T_j = \left(\bar{y}_j / Y_{mean}\right) \times T_{mean} \quad (2)$$

where

T_j = total berry yield (kg) in year *j* ($j = 1997, \ldots, 2008$)

Y_{mean} = arithmetical mean value calculated on the basis of mean annual berry yields (kg ha^{-1}) (see Fig. 3)

T_{mean} = total berry yield during an average crop year (kg) (see Turtiainen et al. 2007)

$\bar{y}_j$ as in Eq. 1

Naturally, total berry yield for a very good crop year, or the best berry year between 1997 and 2008 (T_{max}), could be estimated by multiplying T_{mean} by (Y_{max}/Y_{mean}), where Y_{max} = maximum of the nationwide mean annual berry yields during the period of twelve years (kg ha^{-1}) (see Fig. 3). Total berry yield for a very poor crop year (T_{min}) was calculated correspondingly so that Y_{max} was replaced by Y_{min} which is a minimum of the nationwide mean annual berry yields between 1997 and 2008 (kg ha^{-1}) (see Fig. 3).

2.2 Berry Picking Data

In 1997, a questionnaire concerning NWFP collection was sent to 6849 Finnish households (for a more detailed description of data collection see Saastamoinen et al. 2000, Kangas 2001a). After one callback, a response rate of 59.8% was obtained. For the 1998 study a smaller sample of 1858 was extracted from the sampling frame of 1997. In 1999 the sample size was 1913. The response rates for two latter years were 68.7% and 67.4% respectively.

In 1997 the questionnaire form was more comprehensive compared to the two latter years. In

1998 and 1999 the questionnaire form included only questions concerned with the quantities of wild berries and mushrooms collected, while in 1997 the form also included several questions concerning other NWFPs. In addition, the questions, which concerned the amounts of wild berries picked, were more detailed in 1997. For example, the households included in the sample were asked to identify not only the total quantities of berries picked (according to the species) but also the quantities of berries they had collected in different municipalities. This information was very useful in this study since when the aim is to estimate regional utilisation rate for a certain berry species it is essential to know the amount of berries that are collected in the area in question (berries may have been collected not only by local inhabitants but also by people from other regions).

As mentioned earlier, Saastamoinen et al. (2000) presented nationwide figures related to berry picking in Finland for the years 1997 and 1998. In this study, the total amounts of bilberries and cowberries picked by Finnish households were calculated in detail for the year 1999. In this calculation the survey results for 1997 were used in the analysis of figures for 1999 (cf. Saastamoinen et al. 2000). It was found that 951 households had responded to the questionnaires for both years. The changes that occurred in the quantities collected by these households were assumed to be representative of the whole sample, and so the results for 1997, including the non-response adjustment, were multiplied by the ratios calculated. According to calculations, the total quantity of bilberries picked in 1999 was 5.9 million kg and the corresponding quantity for cowberry was 19.4 million kg.

2.3 Utilisation Rates of Bilberries and Cowberries

National utilisation rates of both berry species during three different berry years were calculated by dividing the amounts of bilberries and cowberries collected by Finnish households in year j ($j = 1997, \ldots, 1999$) by the total berry yields of these species. Total berry yields for each year j were determined by using Eq. 2. It is worth mentioning that year 1997 was the best bilberry year between 1997 and 2008 (Fig. 3) and, therefore, $\bar{y}_{1997}$ was equal to $Y_{\max}$.

Regional utilisation rates were calculated for so-called MARSI regions (case a, Fig. 1A). Food & Farm Facts Ltd (Elintarviketieto Oy) collects annual statistics on quantities and values of wild berries and mushrooms bought by organised trade and industry. These MARSI statistics have been collected since 1977 and are reported for the whole country and also for the four regions (Fig. 1A). Therefore, it was natural to apply this MARSI division in the present study also. Regional utilisation rates were also estimated for five areas that were created for the purposes of this study (case b, Fig. 1B). In the latter case, southernmost and westernmost parts of Finland (i.e. Forestry Centres 1–4, see Fig. 1) were separated as its own area because these parts of the country are more densely populated if compared to other areas of Finland (Table 2). Thus, both "western Finland" and "eastern Finland" are smaller in case b than a (Fig. 1). The two northernmost regions (Oulu-Kainuu and Lapland) are, instead, equal to each other in both cases.

Calculation of regional utilisation rates consisted of three steps (the same procedure was applied to both cases a and b). In the first stage, the quantity of bilberries (cowberries) collected in region k ($k = 1, \ldots, K$; case a: $K = 4$, and case b: $K = 5$) in 1997 was estimated (i.e. $\hat{\tau}_k$). In this study, the regions could be considered as subpopulations (cf. Thompson 2002, p. 45). Let n_k be the number of households in the sample that picked bilberries (cowberries) in the kth region. Further, let q_{ki} be the amount of bilberries (cowberries) (kg) picked by household i in region k (in the sample). Then the subpopulation total in the sample (i.e. τ_{ks}, or total amount of berries collected in region k in the sample) could be calculated as follows:

$$\tau_{ks} = \sum_{i=1}^{n_k} q_{ki} \tag{3}$$

Note that τ_{ks} is a sum of two components, τ_{ks1} and τ_{ks2}, where τ_{ks1} refers to the part of τ_{ks} that was picked by households that belonged to the kth region and τ_{ks2} to the part of τ_{ks} that was picked by households who were coming from other geographical regions of Finland.

Table 2. Population densities and unemployment rates in the regions studied (Statistical yearbook… 1998). The figures are presented for a) four regions based on MARSI division (Fig. 1A) and b) five areas which were created for the purposes of this study (Fig. 1B).

Region	Population density (inhabitants/km^2)	Number of inhabitants per productive land area (inhabitants/km^2) [1)]	Unemployment rate in 1997 (%)
Western Finland [a]	37.8	56.5	11.5
Eastern Finland [a]	15.7	19.8	14.5
Southern Finland [b]	50.9	84.5	10.8
Western Finland [b]	20.4	27.1	13.8
Eastern Finland [b]	12.4	15.3	15.6
Oulu-Kainuu [a, b]	8.0	9.6	17.1
Lapland [a, b]	2.1	3.1	20.4
National average	16.9	23.2	12.7

[1)] Productive land area refers to those mineral soil and peatland sites that are potential with respect to bilberry and cowberry production (see Turtiainen et al. 2005, p. 27; Turtiainen et al. 2007, p. 98). These mineral soil and peatland sites include, at least to some extent, fertile berry plants.

Table 3. Total yields of bilberries and cowberries during an average crop year (Turtiainen et al. 2007) and ranges of variation of the total yields (i.e. minimum and maximum in million kg). The figures are presented for a) four regions based on MARSI division (Fig. 1A) and b) five areas which were created for the purposes of this study (Fig. 1B).

Region	Total yield of an average crop year (mill. kg)		Range of variation (mill. kg)	
	Bilberry	Cowberry	Bilberry	Cowberry
Western Finland [a]	48.2	67.8	24.1…82.0	33.9…101.6
Eastern Finland [a]	35.6	47.4	17.8…60.5	23.7…71.1
Southern Finland [b]	28.9	36.9	14.4…49.1	18.4…55.3
Western Finland [b]	26.1	39.7	13.0…44.3	19.8…59.5
Eastern Finland [b]	28.8	38.7	14.4…49.0	19.3…58.0
Oulu-Kainuu [a, b]	36.3	56.8	18.2…61.7	28.4…85.2
Lapland [a, b]	63.5	85.2	31.8…108.0	42.6…127.8
Total	183.6	257.2	91.8…312.1	128.6…385.7

The following equation was used to estimate $\hat{\tau}_k$:

$$\hat{\tau}_k = \left(\tau_{ks} \Big/ \sum_{k=1}^{K} \tau_{ks} \right) \tau_{1997} \qquad (4)$$

where τ_{1997} is the amount of bilberries (cowberries) collected in Finland in 1997 (see Saastamoinen et al. 2000 and Kangas 2001a).

In the second stage, total berry yields of an average crop year in region k (Table 3) were calibrated for the year 1997 by using Eq. 2. It is important to note that in this study multipliers $\overline{y}_j / Y_{\text{mean}}$ (see Eq. 2), which were estimated on the basis of national MASI data, were utilised in the calibration at both national and regional levels.

Finally, regional utilisation rates, for bilberry and cowberry separately, were defined as a proportion of estimates produced in steps (1) and (2). Standard methods were employed to calculate 95% confidence intervals for the utilisation rates.

3 Results

3.1 Bilberry and Cowberry Production During Good and Poor Berry Years

It was calculated that during a good berry year (like 1997) total bilberry yield in Finland is 1.7 times greater than an average berry year. The corresponding ratio Y_{max}/Y_{mean} for cowberry is 1.5 (year 2005 was the best cowberry year during the period between 1997 and 2008; see Fig. 3).

In a poor berry year, total bilberry and cowberry yields in Finland are no more than 50% of the yields of an average crop year (i.e. $Y_{min}/Y_{mean} = 0.5$). The ratio Y_{min}/Y_{mean} is equal for both berry species even though variables "the poorest crop year during the period of 1997 to 2008", "Y_{min}" and "Y_{mean}" were different for both species (for bilberry, they were 2004, 12.0 kg ha^{-1} and 22.3 kg ha^{-1} respectively, and for cowberry, 2008, 12.4 kg ha^{-1} and 22.7 kg ha^{-1} respectively).

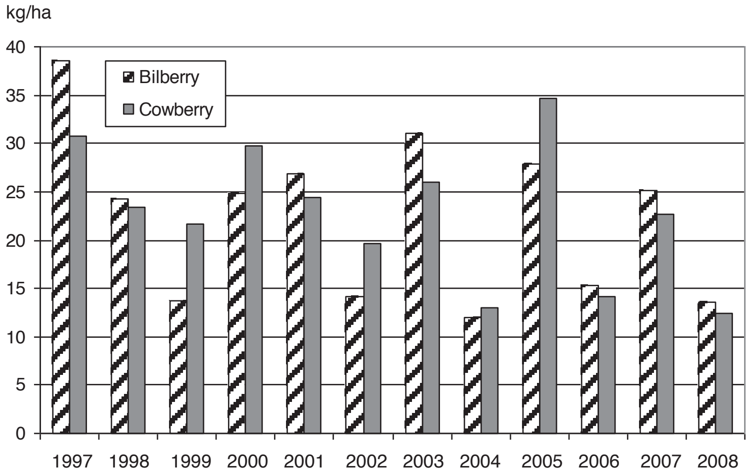

Fig. 3. Nationwide mean annual bilberry and cowberry yields (kg ha^{-1}) on the berry sample plots of different forest stands between 1997 and 2008.

Table 4. Regional and national utilisation rates of bilberries and cowberries in 1997 (95% confidence intervals for utilisation rates are given in parentheses). The figures are presented for a) four regions based on MARSI division (Fig. 1A) and b) five areas which were created for the purposes of this study (Fig. 1B). Utilisation by local inhabitants refers to the part of τ_{ks} that was picked by households of region k (τ_{ks} = amount of berries collected in region k in the sample, see Eq. 3).

Region	Utilisation rates in 1997 (%)		Utilisation by local inhabitants in 1997 (%)	
	Bilberry	Cowberry	Bilberry	Cowberry
Western Finland [a]	5.2 (4.5; 5.9)	5.7 (4.8; 6.6)	99	99
Eastern Finland [a]	9.2 (8.1;10.3)	11.5 (9.2; 13.8)	94	88
Southern Finland [b]	6.5 (5.5; 7.5)	6.4 (5.1; 7.7)	99	99
Western Finland [b]	4.4 (3.7; 5.1)	5.2 (4.2; 6.2)	88	92
Eastern Finland [b]	9.5 (8.2; 10.8)	12.5 (8.6; 16.4)	93	86
Oulu-Kainuu [a, b]	8.8 (6.5; 11.1)	12.3 (8.9; 15.7)	98	98
Lapland [a, b]	2.6 (2.0; 3.2)	3.9 (2.8; 5.0)	96	97
Total	5.8 (5.3; 6.3)	7.6 (6.9; 8.3)		

Thus, on the national level total bilberry yield could vary from 91.8 to 312.1 million kg (Table 3). In the case of cowberry, the range of variation in total yields is from 128.6 to 385.7 million kg (Table 3).

3.2 Utilisation Rates of Bilberries and Cowberries

In 1997, national utilisation rates of bilberries and cowberries were 5.8% and 7.6% respectively (Table 4). In 1998, when berry crops of both species were close to an average level (Fig. 3), 5.6% of the total bilberry and 9.7% of the total cowberry yields were picked (confidence intervals (4.8; 6.3) and (8.3; 11.2) respectively). The year 1999 was one of the poorest bilberry years during the period between 1997 and 2008, and cowberry yields also remained below average (Fig. 3). During this year utilisation rates of bilberries and cowberries were 5.2% and 7.9% respectively (confidence intervals were (3.4; 7.0) and (6.4; 9.4) respectively).

In 1997, bilberries and cowberries were utilised most intensively in the eastern parts of the country and in the Oulu-Kainuu region (Table 4). In these areas the utilisation rate of bilberries was approximately 9% and the corresponding estimate for cowberries was approximately 12%. In Lapland, only a few percent of the total berry yields of each species were collected. Utilisation of bilberries and cowberries was a bit more intensive in “southern Finland” than in “western Finland” (Table 4, case b). Clearly most part of the berries were picked by local inhabitants in each region (Table 4).

4 Discussion

This study was a continuation of the studies of Turtiainen et al. (2005, 2007) and also, to a smaller extent, that of Saastamoinen et al. (2000). As Turtiainen et al. (2005, 2007) calculated total bilberry and cowberry yields for an average berry year in this work total berry yields of these two species were calibrated for different crop years (abundant and poor) by using the MASI data of the Finnish Forest Research Institute. It has previously been found that berry yields calculated on the basis of MASI data are higher than average due to the sampling method (Miina et al. 2009). In other words, MASI sample plots have been placed subjectively so that both a high coverage of a species and good berry crops have been observed in earlier years (Salo 1999). Therefore, it was found justified to use multiplier “coverage of a species” in Eq. 1 so that a more realistic picture of mean annual berry yields (kg ha^{-1}) was obtained (see Fig. 3). Maybe it is worth noting that multiplier c (see Eq. 1) is not crucial in the calculation of total berry yields as it cancels out in Eq. 2.

Despite the subjective nature of the sampling method, information gathered on MASI sample plots for different forest stands is applicable when exploring temporal variation of bilberry and cowberry yields on mineral soil sites. For example, if weather conditions etc. are not advantageous with respect to berry production during a certain year, it can be presumed that berry yields will be poorer than average in all kinds of forest sites, including those which are typically good growing sites for bilberry and cowberry (cf. MASI sample plots). In the case of peatlands, however, application of MASI data to calibration purposes may, in some cases, be problematic or even misleading. One reason for this is that berries that grow on peatlands only seldom suffer from dryness (Salo 1988). In other words, during dry summers berry yields on mineral soil sites may remain lower than average but on peatland sites they may be normal, or at least close to normal. In this study, however, MASI data was considered to apply to both mineral soils and peatlands because there is a lack of empirical long-term measurements on the yields of bilberries and cowberries on peatlands (see e.g. Turtiainen et al. 2007). On the other hand, the significance of peatlands to the total yields of bilberries and cowberries is not very high. In Finland, no more than 8% of the total (i.e. mineral and peatland soil) bilberry yield and 5% of the total cowberry yield is produced by peatlands annually (Turtiainen et al. 2007).

One can question whether the best berry years between 1997 and 2008 were actually very abundant crop years. A corresponding question naturally concerns the poorest crop years during that period. It is obvious that both bilberry and cowberry yields were abundant in large areas of

Finland in 1997 since there were no late frosts, pollination was successful and showers of rain and warm seasons were optimal with respect to berry production (Salo 1999). In 2005 the cowberry crop was even higher than in 1997. In 2004 bilberry yields remained low because of frosts as well as rainy and windy weather conditions in spring, which in turn resulted in unsuccessful pollination. The year of 2008, however, did not necessarily represent the lowest extreme with respect to cowberry production (e.g. Maa- ja metsätalousministeriö 2009). These findings from nationwide forecasts of the Finnish Forest Research Institute and tens of Finnish newspapers are in line with the domestic berry trade statistics (e.g. Finnish Statistical… 2008, Maa- ja metsätalousministeriö 2009), though it is important to bear in mind that crop level is only one factor affecting the intensity of commercial wild berry picking, the other major factor being the market price of berries, reflecting inversely the scarcity or abundance of annual crops. Thus, it can be presumed that the total yield of cowberries during a poor crop year (crop failure) may actually be a little lower than presented in this study. Consequently, one could conclude that there is still a need to collect a longer term series on MASI sample plots (from 15 to 20 years) so that temporal variations of berry yields could be determined more accurately.

Raatikainen et al. (1984) and Salo (1994) have previously explored temporal variations of the most common forest berries in Finland. The first mentioned study was based on empirical measurements conducted in the areas of five municipalities during three separate years and the latter one was based on expert knowledge. When comparing the total bilberry yields of this study (Table 3) to estimates of Raatikainen et al. (1984) and Salo (1994) according to which annual bilberry production in Finland varies from 150 to 200 mill. kg it can be seen that the earlier figures underestimate temporal variations in total bilberry yields. The cowberry yield estimate of Raatikainen et al. (1984), i.e. 180–200 mill. kg, appears to be low (cf. Turtiainen et al. 2007) and most probably does not include the best and the poorest crop years. An expert estimate of Salo (1994), i.e. 200–500 mill. kg, is more optimistic than the calculations of this study but the range of variation in annual cowberry yields (approximately 250–300 mill. kg) is of the same magnitude in both studies.

In Sweden, effects of various silvicultural measures on bilberry and cowberry yields were studied on 1760 permanent sample plots which were located in different parts of the country during an 11 year period between 1976 and 1986 (Kardell and Eriksson 1990). It was found that during abundant berry years bilberry production was an average of two to three times bigger than poor years. In the case of cowberry, the ratio between good and poor years was a bit lower. The results of this study are quite similar ($Y_{\max} / Y_{\min}$ was 3.2 for bilberry and 2.8 for cowberry). There is one obvious explanation for the higher annual variations in bilberry yields. As bilberry flowering begins at the end of May or in the beginning of June, or even earlier (e.g. Eronen 2004) there is a high risk that the flowers get frostbitten due to spring frosts. Cowberry, however, flowers later and usually does not suffer from frosts. In future, the negative effect of frosts on bilberry yields may become an even more serious problem due to climatic warming and earlier springs (see e.g. Karlsen et al. 2007).

National utilisation rates of bilberries and cowberries were calculated for three different berry years. It was interesting to observe that in each year approximately the same proportion of the total yield of bilberries was collected (i.e. 5–6%). Utilisation rates of cowberries were also quite constant from year to year varying from approximately 8% (in 1997 and 1999) to nearly 10% (in 1998). In the case of cowberry, the estimate calculated for the year 1998 slightly differed from those calculated for other years (see confidence intervals in chapter 3.2 and Table 4). However, any relationship between the crop level and the variable "utilisation rate of berries" could not be found even though the picked amounts (in kilograms) tend to be clearly higher during good crop years compared to poorer years (see also Rossi et al. 1984). The utilisation rates calculated in this study are not very far from the earlier rough estimates, i.e. 4% for bilberry and 11% for cowberry (Hiirsalmi and Lehmushovi 1993). Utilisation of bilberries, however, seems to be a bit more intensive and utilisation of cowberries a bit less intensive than presumed.

Regional utilisation rates were calculated for a

Table 5. Utilisation rates of bilberries and cowberries (in percent) calculated in different studies. Utilisation rates are regional, i.e. they have been calculated either for a certain municipality or district (W = western Finland, E = eastern Finland, N = northern Finland, or Lapland; see Fig. 1A).

Source	Study year	District	Utilisation rate (%)	
			Bilberries	Cowberries
Raatikainen (1978) [1)]	1976	Pihtipudas (W)		7
Raatikainen and Raatikainen (1983) [2)]	1977	Pihtipudas (W)	1.8	
Rossi et al. (1984)	1978	Lavia (W)	14	11
Rossi et al. (1984)	1978	Mänttä (W)	21	44
Rossi et al. (1984) [3)]	1979	Enonkoski (E)		9
Rossi et al. (1984)	1979	Konnevesi (W)	7	9
Rossi et al. (1984)	1981	Ilomantsi (E)	5	19
Höglund (1987)	1985	Jäppilä (E)	1.0	3.2
Höglund (1987)	1985	Enonkoski (E)	1.6	6.7
Höglund (1987)	1985	Kerimäki (E)	2.7	7.8
Höglund (1987)	1985	Mikkeli (E)	3.2	9.4
Höglund (1987)	1985	Savonlinna (E)	7.6	21.5
Kujala et al. (1987)	1986	Lapland [4)]	1.3	2.2
Kujala et al. (1989)	1987	Kainuu and North Ostrobothnia [4)]	2.8	8.0
Kujala et al. (1989)	1988	Kainuu and North Ostrobothnia [4)]	4.5	4.8
Saastamoinen and Lohiniva (1989)	1983	Rovaniemi region (N)	3	4

[1)] Only cowberries were studied
[2)] Only bilberries were studied
[3)] Utilisation rate of bilberries could not be calculated
[4)] See Fig. 1A

good berry year (1997). Usually regional variation in berry yields is high (e.g. Kolupaeva and Skrjabina 1979, Salo 1999) but during this particular year both bilberry and cowberry yields were either very abundant, abundant or at least above average in all regions of Finland (cf. Fig. 1 and Salo 1999, p. 42). Therefore, all regional berry yields (bilberry and cowberry separately) were calibrated for a good crop year by using the same multiplier $\bar{y}_{1997} / Y_{\text{mean}}$ (see Eq. 2) throughout the country. As mentioned earlier (chapter 2.3), this multiplier was estimated on the basis of national MASI data. This procedure, as well as the fact that MASI sample plots are not uniformly divided across the country (see Fig. 2), have most probably affected regional utilisation rates to some extent but it is difficult to conclude how much. In future studies, it would be reasonable to pay more attention on the spatial variation of berry yields so that regional utilisation rates of wild berries during different crop years could be determined more accurately. For example, it would be appropriate to use regional data in the calibration. This naturally requires that there is sufficient data for reliable estimates on the regional yield levels to be produced.

In most regions utilisation rates of bilberries and cowberries were low; a result found also in many previous studies (see Table 5). It is worth mentioning that utilisation rates calculated by Raatikainen (1978), Raatikainen and Raatikainen (1983), Rossi et al. (1984) and Höglund (1987) are concerned with relatively small areas (municipalities). Thus, in some cases utilisation rates of wild berries can rise if they have been calculated for densely populated small areas (e.g. Mänttä and Savonlinna municipalities in Table 5; see also Rossi et al. 1984 and Höglund 1987).

The figures calculated by Kujala et al. (1987, 1989) and Saastamoinen and Lohiniva (1989) are concerned with large regions (Table 5) and are therefore comparable with the results of this study. When considering Lapland, it can be seen that utilisation rates of bilberries and cowberries, which have been estimated earlier by Saastamoinen and Lohiniva (1989), are included in the 95% confidence intervals (Table 4). The estimates of Kujala et al. (1987) are low and contain a lot of uncertainty due to very rough total yield estimates (Kujala et al. 1987). In Oulu-Kainuu region, utilisation of berries of both species was found to be more intensive than earlier estimated (cf. Tables 4 and 5). This result is not a surprise since MARSI statistics indicate that Oulu-Kainuu region has traditionally been the main area of commercial wild berry picking in Finland (e.g. Malin 1998). In 1997, for example, 69% (i.e. 2.1 mill. kg) of the total quantity of bilberries bought by organised trade and industry came from Oulu-Kainuu region, and the corresponding figure for cowberry was 61%, or 4.7 mill. kg (Malin 1998). One potential explanation for high picking intensity, besides strong tradition in this area, is the fact that in Oulu-Kainuu region (especially in Kainuu) the unemployment rate is high (Table 2). It has been found that berry picking, commercial berry picking in particular, is more active among households whose members are suffering from unemployment compared to households in full employment (e.g. Kangas 2001b, Saastamoinen et al. 2005).

The effect of population density on picking intensity (discussed earlier in the context of small areas) is supported by the results of this study although calculated for large regions. When "western Finland" (see Fig. 1A, i.e. MARSI division) was divided into two areas developed for the purposes of this study ("western Finland" and "southern Finland"; the latter one includes also Forestry Centre of Southeast Finland, see Fig. 1B), it was found that utilisation of both bilberries and cowberries was a bit more intensive in densely populated "southern Finland" compared to "western Finland" (Tables 2 and 4). In addition, almost all of the berries picked in "southern Finland" (99%) were collected by local people (Table 4). In 1997, the unemployment rate was below the national average in "southern Finland" while in "western Finland" it was above the national average (Table 2). Thus, the differences in the utilisation rates between these two areas could most probably be explained by the fact that a number of inhabitants per land area which is potential with respect to bilberry and cowberry production is about three times higher in "southern Finland" than in "western Finland" (Table 2).

It is important to keep in mind that the berry picking data used in this study was from the end of the twentieth century. For the past few years a large part of the commercial wild berry harvest (bilberry, cowberry, cloudberry) for berry processing enterprises has been collected by foreign pickers following an earlier trend in Sweden (e.g. Richards and Saastamoinen 2010). Foreign pickers previously mostly came from the Ukraine, Belarus and Russia (from the late nineties), but increasingly they have come from Thailand. The increase in berry pickers from Thailand has been exponential, from a little less than a hundred pickers in 2005 to about 1900 in 2008, and Thai berry pickers along with those from other countries totalled over 4000 foreign pickers in 2008 (Lacuna-Richman 2008; also information gained from newspapers). So far, only limited research results exist concerning the migration of collectors but it has been estimated that nowadays at least half of commercial berries are picked by foreigners (in 2009 even 80–90%) (S. Moisio, pers. comm.; also information gained from newspapers). In Sweden, the corresponding proportion is as high as 95% (S. Moisio, pers. comm.). Thus, it is quite obvious that foreign pickers have affected both regional and national utilisation rates of wild berries and the estimates of this study (Table 4) describe the situation before the arrival of foreign pickers rather than the current situation. In future studies, the phenomenon of seasonal migrant pickers should be considered so that it can be estimated, for example, how great the regional concentration of foreign and native commercial pickers is in the same northern and eastern areas of Finland and how this affects utilisation rates, the economic profitability of berry picking and also ecological sustainability of wild berry resources.

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