J. Raptor Res. 36(2):128–135

A LINE TRANSECT SURVEY OF WINTERING RAPTORS IN THE WESTERN PO PLAIN OF NORTHERN ITALY

GIOVANNI BOANO[1]
Mus. Civ. St. Nat., P.O. Box 89, 10022 Carmagnola (TO), Italy

ROBERTO TOFFOLI
Via Tetto Mantello 32, 12011 Borgo S. Dalmazzo (CN), Italy

ABSTRACT.—The raptor population wintering in lowland farmland of northwestern Italy was monitored during the winters of 1998–99 and 1999–2000 by means of a roadside vehicle survey. To estimate the density of wintering raptors, we recorded perpendicular distances of the birds from transect lines. Seven species of raptors were recorded, but a sufficient number of observations to estimate density was collected only for the Common Buzzard (*Buteo buteo*). The extensive rice fields in the eastern part of the region and some other restricted areas, rich in humid meadows and scattered woodlots, showed high Common Buzzard densities (1.1–1.6 birds/km^2), but the other cultivated areas, mainly cornfields, had a significantly lower density (0.2 birds/km^2). On the basis of these data, we estimated a wintering population of Common Buzzards of the lowland farmland, covering about 6700 km^2 in the Piemonte region of northwestern Italy of 3700 (3200–4400) birds.

KEY WORDS: *Common Buzzard;* Buteo buteo; *raptors; winter survey; transect; Italy.*

Un estudio con transectos lineares de Rapaces invernantes en la planicie occicental del Po en el norte de Italia

RESUMEN.—La población de rapaces invernando en zonas agrícolas bajas del noroeste de Italia fue monitoreada durante los inviernos de 1998–1999 y 1999–2000 por medio de un estudio hecho desde un vehículo. Para estimar la densidad de rapaces invernantes registramos las distancias perpendiculares de estas aves a transectos en línea. Siete especies de rapaces fueron registradas, sin embargo un numero suficiente de observaciones para estimar densidades solo fue colectado para el gavilán común (*Buteo buteo*). Los extensos campos de arroz en la parte oriental de la región y algunas otras áreas restringidas, ricas en prados húmedos y bosquecillos dispersos, mostraron altas densidades de gavilanes comunes (1.1–1.6 aves/km^2), pero en las otras áreas cultivadas, principalmente campos de maíz, tuvieron una densidad significativamente mas baja (0.2 aves/km^2). En base a estos datos, estimamos una población invernante de gavilanes comunes en las granjas de zonas bajas, que cubrían cerca de 6700 km^2 en la región Piemonte del noroeste de Italia de 3700 (3200–4400) aves.

[Traducción de César Márquez]

Over 40% of Europe's area is occupied by lowland farmlands, which offer important habitats for many birds in the breeding season and, even more, in winter. However, agricultural intensification and modern farming practices, fostered by international policies, is rapidly eliminating meadows, hedges, woodlots, and orchards, dramatically affecting the carrying capacity of most birds associated with these farmlands (Tucker and Heath 1994). Many raptor species traditionally associated with agricultural or pastoral landscapes such as kestrels (*Falco* spp.), harriers (*Circus* spp.), and buzzards (*Buteo* spp.) are known to be affected in a number of ways by land use intensification (del Hoyo et al. 1994). Some of these species, such as the Common Buzzard (*Buteo buteo*), seem to be recovering in Europe from low populations due to past persecution and pesticide effects, while others, such as the Eurasian Kestrel (*Falco tinnunculus*), do not show similar positive trends (Hagemeijer and Blair 1997). Their populations in intensively-cultivated areas may be regarded as important ecological indicators and the monitoring of their trends as an important conservation task.

The Po Plain in northern Italy is an intensively-

[1] E-mail address: gboano@tiscali.it

cultivated, inhabited area and, notwithstanding low winter temperatures (below the 2°S isotherm in January), is regarded as one of the primary wintering areas in Italy for some raptor species, namely Hen Harrier (*Circus cyaneus*), Eurasian Sparrowhawk (*Accipiter nisus*), Common Buzzard, Eurasian Kestrel, and Merlin (*Falco columbarius*) (Chiavetta 1986). However, objective assessments of their winter numbers and trends are generally lacking, due to scarcity of surveys. Information is mainly limited to bird-distribution atlases covering part of the Po Plain (e.g., Fornasari et al. 1992, Cucco et al. 1996).

Changes in land use, potentially influencing raptor distribution and numbers, are expected in the next few years, mainly as a consequence of the European community agricultural politics (e.g., Communication of the European Community Commission, number 278/7.6.2000). Therefore, we started a project to estimate the wintering raptor populations over representative portions of the Po Plain, to provide a basis for future evaluations of trends.

A vehicle road survey, driving at slow speed, is a common method to count diurnal raptors, especially in open habitats and in winter season (Thiollay 1976, Fuller and Mosher 1981). From these counts, an index of the relative abundance can be obtained usually expressed as birds per kilometer.

Comparisons of indices of abundance among areas, times, and different species could be made only by assuming similar detection probabilities, an assumption rarely met for species of different sizes and detectability or in habitats with different vegetative cover (Burnham et al. 1981). Moreover, detection probability might change from one year to the next in the same habitat (Andersen et al. 1985).

Comparisons of density estimates avoid this assumption, but generally require labor-intensive methods, applicable only on limited areas and with territorial birds. A way of obtaining density estimates of wintering raptors over large areas is use of a "distance" sampling method (Buckland et al. 1993). Distance sampling consists essentially of line transects with the registration of the perpendicular distances from the objects of interest to the line (Burnham et al. 1981) or point counts measuring the radial distance from the observer to the objects (Reynolds et al. 1980, Buckland 1987).

In spite of their potential usefulness, distance methods have not been applied commonly to raptor surveys until recently. Specifically, Andersen et al. (1985) investigated raptor densities in a military reserve of Colorado with line transects and Hall et al. (1997) estimated the population of the endangered Hawaiian Hawk (*Buteo solitarius*) with point counts. Point counts, however, generally are less effective for monitoring rare species. Transects may be more effective because birds can be sampled continuously without breaks. In addition, the variance of the counts are greater with point counts than with distance transects (Buckland et al. 1993: 302). On the basis of these considerations and previous experience with point counts, we decided to use line-transect sampling and to evaluate the practicality and efficiency of this method in our field situation.

STUDY AREA AND METHODS

The study area is the intensively-cultivated western Po River Plain included in the region Piemonte (Italy). The main crops in the western half of the region (provinces of Torino and Cuneo) are corn, wheat, and hay; rice fields dominate in the northeastern portion (provinces of Vercelli, Biella, and Novara) and wheat in the southeastern quarter (province of Alessandria).

We conducted the survey in two consecutive winters, in the first winter (19 December 1998–28 January 1999) we worked only in the western part (Cuneo and Torino provinces); in the second winter (17 December 1999–22 January 2000) the sample was extended to the eastern rice fields (Vercelli, Biella, and Novara provinces).

During the 1999–2000 winter, we stratified (Sutherland 1996) the sample according to the topography and to the prevailing conditions of the rural landscape. We identified two strata corresponding to the geographically well-separated western and eastern plains characterized by the prevailing cultivation (maize and rice, respectively); each of these were then divided in two subareas, mainly on the basis of different intensity of agricultural utilization. Corine land cover digital maps (level 3) and Geographical Information System (GIS) analysis allowed us to calculate the area of each strata defined as follows (Fig. 1).

Western cornfields (WC): an area of intensive agriculture with wheat, meadows, soybean, but mainly maize fields, extending over the main part of the plain between the cities of Turin and Cuneo (estimated area 2700 km^2),

Western meadows (WM): included in the preceding area, but characterized by a greater habitat diversity, with presence of humid meadows, small uncultivated fields, poplar (*Populus* spp.) plantations and natural woodlots, due to the poor agricultural quality of soils (IPLA 1982) (estimated area 500 km^2);

Eastern rice fields (ER): an area with mostly intensive rice fields, almost treeless except for a few isolated poplars or oaks (*Quercus* spp.) and a single 4-km^2 forest patch (estimated area 1250 km^2);

Eastern heathlands (EH): an area with recently developed rice fields, a growing proportion of woodland, especially

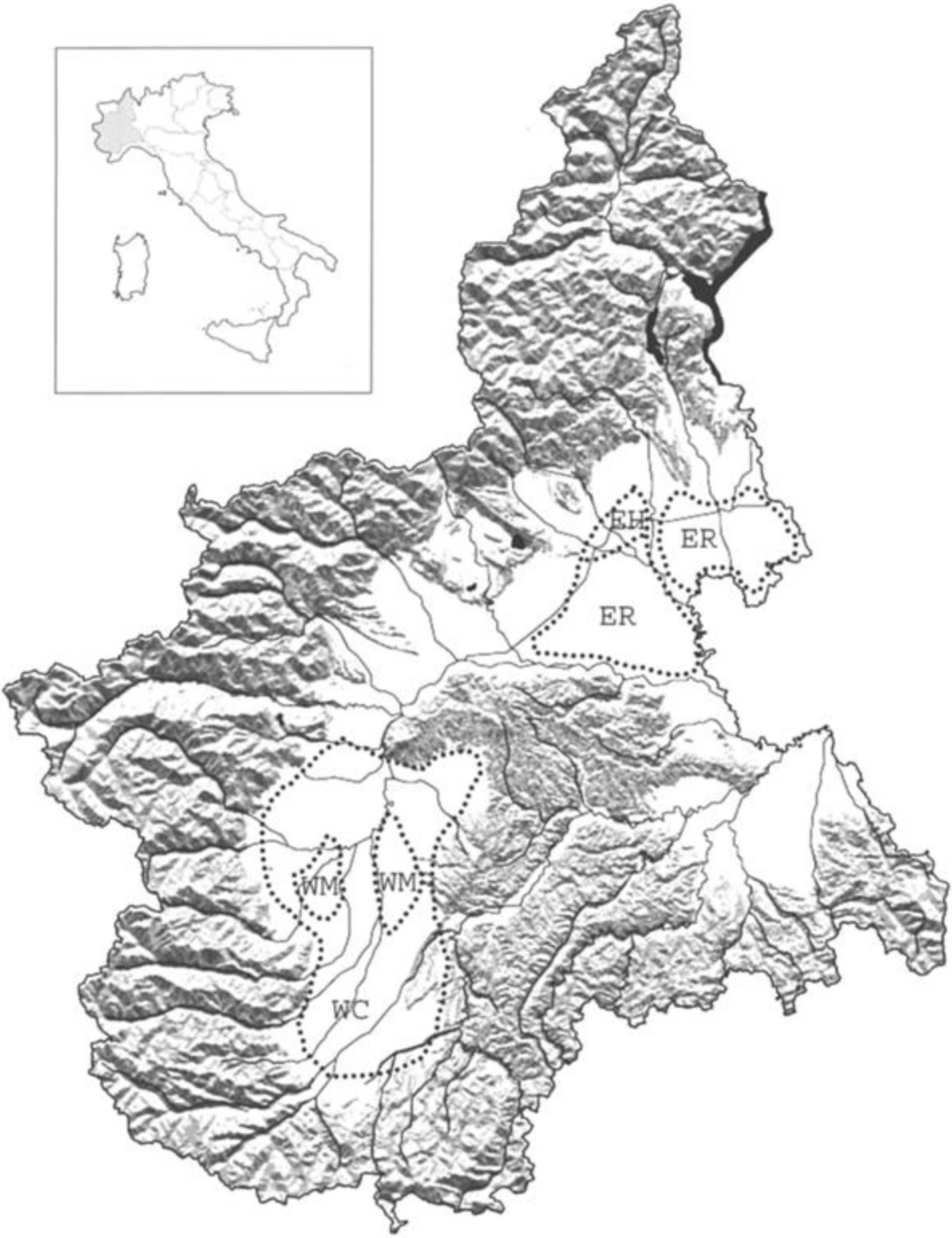

Figure 1. The study area in the western Po Plain with the four strata (WM = western meadows, WC = western cornfields, ER = eastern rice fields, EH = eastern heathlands). Slope and mountain areas in gray.

along rivers, and with residual heathland of ancient pastoral origin (estimated area 250 km^2).

We established linear transects and recorded transect length, species observed, and the perpendicular distances between the transect line and birds on both sides of the transect.

To obtain unbiased and representative estimates of densities for the whole area, according to Burnham et al. (1981) and Buckland et al. (1993), it is necessary to consider the following assumptions:

(1) *The detection probability of the birds on the transect line should be 1.* This is the most important assumption of the method: the lack of detection of some individuals just on (or very nearby) the transect line biases the results; but the method explicitly allows some animals to go undetected away from the transect line. In practice, it is necessary to ascertain that no birds fly from the transect line undetected. This condition was not difficult to meet with medium to large raptors (e.g., Common Buzzard) in open country, but may be problematic with smaller or more elusive species (e.g., Eurasian Sparrowhawk, Merlin).

(2) *The perpendicular distances from the transect and each observed bird should be estimated accurately.* The authors alternatively assumed the roles of observer and driver and the accuracy of the observations and measurements was improved with slow driving (15–40 km/hr) and the use of binoculars (LEICA Geovid 7 × 42 BDA) that estimate the distances with a laser telemeter (precision of ±1 m; range 25–1000 m). The distances of birds under 25 m were paced or estimated visually. Birds flying away from the line due to the approaching vehicle were measured at the perpendicular distance from transect where they were first seen. A few birds flying independently from our approach were recorded when they came abeam of the vehicle. All the birds observed were counted with no truncation distance, and, due to the open habitat, we saw birds up to 550 m, but for the DISTANCE analysis we truncated the data at 450 m to eliminate outliers.

(3) *The transect should be allocated randomly with respect to the distribution of the counted animals.* For the estimated densities to be representative of the true densities, the transects should be allocated independent of the bird distribution. This requisite is the most difficult to accomplish. Because we could obtain a sufficient number of observations only with very long transects, we were required to travel along existing roads.

Generally road transects should be avoided because they are likely to be unrepresentative of the entire area (Buckland et al. 1993) due to the disturbing effects of traffic that drive away the birds, and because roads sometimes run parallel to power and telephone lines, that may favor higher densities of birds. We tried to reduce these problems by using secondary and dirt roads; moreover, we traveled the routes on days with low traffic such as Sundays and holidays.

During the first winter, the transect selection was influenced by our knowledge of the territory. In the second winter, from the Italian Geographical Militar Institute (IGMI) 1:25 000 maps of the study area, we pre-selected routes crossing the center portions of each map and maintained a prevailing transect direction (east-west or north-south) as much as possible. When we were obliged to change routes for whatever reason, we selected the new route at random. We did not exclude the small country towns (along <2 km of road) from the transects, which occur at a relatively high frequency in the study area.

We counted mainly from 1000–1500 H because in winter the daylight is relatively short: at 1600–1630 H it becomes dark and in the morning fog is often present, so the middle hours of the day are the best conditions for the counts. We did not notice obvious differences of bird behavior during these hours.

During the survey season, the birds were wintering and there was no noticeable movement; the migration in the region lasts from March–May and from August–November for all the species. Mortality due to starvation between the beginning of December and the beginning of February was probably not important because the winters were not particularly hard.

(4) *The observations should be independent of each other.* We did not observe clusters of birds and so the observations were probably independent of each other.

(5) *The length of the survey should be sufficient to detect at least 30–40 and preferably 60–80 animals.* We sampled 455 km of transect in the first winter and 405 km in the second, subdivided into 19 and 18 transects respectively of 10–30 km each. We did not replicate routes, but used different transects for each survey. In a day we sampled 100 km of transect and generally counted one day each week.

During the first winter, we collected sufficient data only to estimate the density of Common Buzzards Therefore, in the second year, we subdivided the effort to sample a sufficient number of Common Buzzards in each strata.

Finally the calculation of the densities and abundances was made with the program DISTANCE 3.5 (Thomas et al. 1998) and the variance was calculated empirically; the program fit a series of functions to the distance data and the model best fitting the data was selected by use of the Akaike Information Criterium (AIC) (Anderson and Burnham 1999).

The comparisons among the estimated densities of the different strata were made with the technique described by Hines and Sauer (1989), implemented in the program CONTRAST.

RESULTS

We counted 251 raptors (Table 1): Common Buzzards, Eurasian Kestrels, Peregrine Falcons (*Falco peregrinus*), and the single Red Kite (*Milvus milvus*) were mostly perched when observed (<5% of buzzards recorded flying); Hen Harriers, Eurasian Sparrowhawks, and Merlins were usually seen flying. Excluding the Common Buzzard, the only species for which we made a sufficient number of observations to estimate density, the indices of

Table 1. Raptors observed in the primary study areas of the western Po Plain, northern Italy, in the winter.

		1998–99		1999–2000			
		WESTERN AREA		WESTERN AREA		EASTERN AREA	
SPECIES		*N*	*N*/km	*N*	*N*/km	*N*	*N*/km
Common Buzzard	*Buteo buteo*	71	0.16	57	0.19	82	0.80
Kestrel	*Falco tinnunculus*	13	0.03	6	0.02	9	0.09
Sparrowhawk	*Accipiter nisus*	6	0.01	1	0.00	3	0.03
Peregrine	*Falco peregrinus*	2	0.00	0	—	2	0.02
Hen Harrier	*Circus cyaneus*	1	0.00	0	—	1	0.01
Merlin	*Falco columbarius*	0	—	1	0.00	1	0.01
Red Kite	*Milvus milvus*	0	—	0	—	1	0.01
Total		93	0.20	65	0.21	99	0.97
Sampling effort (km)			455		303		102

abundance (hawks/km) of all other birds were generally low: in the western part of the area we drove 20–30 km to see one non-buzzard raptor, but the situation was better in the eastern area, where we observed a mean of 1 raptor/6 km.

Common Buzzard Density. Following the guidelines of Buckland et al. (1993:46–51) we analyzed the data with DISTANCE, testing the uniform and half-normal keys alone and with cosine and Hermite adjustments. We selected the best models based on the lowest AIC values for each strata.

Analysis of the data collected during the first winter in the western zone shows a mean density of 0.69 Common Buzzards/km^2 (95% C.I. = 0.51–0.93 hawks/km^2; length of transect = 455 km). However, during the fieldwork we noticed apparent density variation with a high frequency of encounters (about one buzzard per km) in some patches interspersed with large areas with an encounter rate of <1 hawk every 5 km. This observation and the inclusion of the eastern area induced us to stratify the sample in 1999–2000. The analysis of these data showed similar detection curves among strata, as partly expected from the relative homogeneity of the agricultural landscape of the Po Plain. Therefore, we decided to fit the detection function to data pooled across the four strata. As suggested by Buckland et al. (1993), if the AIC of the latter analysis is lower than the sum of the AIC values for the four strata, we can assume a common detection function across strata and estimate encounter rate and density separately by stratum. The AIC of the pooled analysis (395.97) was lower then the AIC sum of the models for each strata (396.89). Thus, we present the histogram of sighting data (Fig. 2) and the estimates for each strata (Table 2).

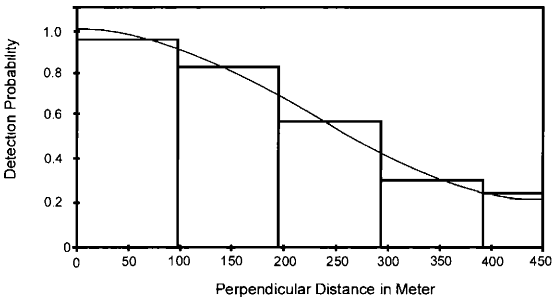

Figure 2. Graphical representation of sighting distances of buzzards from transects (winter 1999–2000) and fitted detection curve (χ^2 = 0.158, df = 3, P = 0.984).

A contrast analysis (Hines and Sauer 1989) among the four estimates indicates a significant density difference among strata (χ^2 = 209.25, df = 3, P < 0.001). This difference seemed to be entirely due to the lower density of hawks in the western cornfields stratum, as no statistical significance was achieved by contrasting the other three strata (χ^2 = 4.54, df = 2, P = 0.10).

DISCUSSION

Our results show that the line-transect method in the study area can, with moderate effort, generate suitable results for the most common species, the Common Buzzard. The other wintering raptors are much scarcer, and only for the Eurasian Kestrel would we likely obtain a sufficient count to estimate density with an effort of 1000–2000 km of transect. Another strategy would be to pool data

Table 2. Density estimates based on a DISTANCE analysis of Common Buzzard data for the winter 1999–2000 (uniform key with cosine adjustment of order 1).

Stratum	Length (L) (km)	N	N/L	SE (N/L)	Density (hawks/km²)	SE (D)	95% C.I. (hawks/km²)
Western cornfields	262	32	0.12	0.02	0.22	0.03	0.16–0.30
Western meadows	41	25	0.61	0.01	1.11	0.07	0.97–1.26
Eastern rice fields	61.7	44	0.71	0.06	1.30	0.13	0.99–1.69
Eastern heathlands	40	35	0.87	0.12	1.59	0.25	1.03–2.45

across years for estimating a detection function, provided no significant difference in detection probabilities among years exists.

We realize that our estimates may only be inferred to the limited areas along the transect roads, but we suggest that the estimates may be a reasonable approximation of the densities typical of the western Po Plain. This suggestion follows from our selection of secondary roads, from the large effective strip width sampled, and from the high density of such secondary roads, irregularly crossing the entire region.

Moreover, the estimates of density obtained for the Common Buzzard were very similar to those obtained near Biella (Table 3) with intensive searches in restricted areas included in our "eastern heathlands" subarea.

Therefore, based on our analysis using DISTANCE, we estimate the wintering Common Buzzard population of the region as follows: 1620 (95% C.I. = 1250–2110) individuals in the eastern rice fields, 400 (260–610) in the eastern heathlands, 600 (440–820) in the western cornfields, and 560 (490–630) in the meadow area, with a combined estimate of 3180 individuals (2690–3760).

Clearly the data demonstrate that cornfields are a less suitable wintering habitat for Common Buzzards (Table 2) than other habitats. However, rice fields seem to be equally suitable as meadows and heathlands. The index of abundances (hawks/km) of these areas are, in fact, much higher than known for other Italian regions and many Mediterranean countries (Table 4). The density estimates (Table 3) are, however, lower than those observed in some central European countries such as France and Germany.

Finally, on the basis of the known distribution of Common Buzzards (Cucco et al. 1996), we specu-

Table 3. Density estimates of wintering Common Buzzards in some European and Mediterranean countries.

Area	Years	Effort (km²)	N/km²	Sources
Biella, Piemonte (Italy)	1983–84 1986–87	36.75	0.67–1.24	Bordignon 1998
Novara, Piemonte (Italy)		88	0.18	Mostini 1981
Vercelli, Piemonte (Italy)			1.9	Ruggieri in Cucco et al. 1996
Po River, Piemonte (Italy)			0.5–1.0	Pulcher in Mingozzi et al. 1988
Lombardia (Italy)			0.007	Canova in Brichetti et al. 1992
Ostholstein (Germany)			0.17–0.23	Westernhagen 1966 in Glutz & Bauer 1980
Mittel and Sud-Mecklenburg (Germany)			1.0–3.5	Jung 1970 in Glutz & Bauer 1980
Baden-Württenberg (Germany)		840	0.9	Jacoby & Schuster in Glutz & Bauer 1980
Oberrheinebene Bodenseegebiet (Germany)			2.0–2.1	Jacoby & Schuster in Glutz & Bauer 1980
Schwabische Alb (Germany)			0.41	Jacoby & Schuster in Glutz & Bauer 1980
Westfalen (Germany)			1.3–5.2	Mester & Prunte 1968 in Glutz & Bauer 1980
Plzeň (Germany)	1993–96	4.2	2.4–5.1	Schropfer 1997
France			1.5–4.0	Nore in Yeatman-Berthelot 1991

Table 4. Indices of abundance of wintering Common Buzzards in some European and Mediterranean countries.

AREA	YEARS	EFFORT (km)	N/km	SOURCES
Cote d'Or (France)	1966–77	10748	0.22	Bloc 1987
Aube (France)	1970–77	24120	0.40	Bloc 1987
Rhone-Alpes (France)	1981–86	?	0.28–0.46	Bloc 1987
Camargue (France)	1972–73 1974–75	240	0.01–0.03	Walmsley in Blondel & Isenmann 1981
Sicilia (Italy)	1977–80	1676	0.04–0.07	Massa 1980
Sicilia (Italy)	1987–90 1993–94	2233	0.06 (0.03–0.14)	Sarà 1996
Sardegna (Italy)	1989–90 1991–92	1630.7	0.09 (0.07–0.12)	Sarà 1996
Basilicata (Italy)	1993–94	818.5	0.06	Sarà 1996
Puglia (Italy)	1993–94	606	0.006	Sarà 1996
Tunisia	1987–88 1989–90	1638	0.005	Sarà 1996

latively generate an estimate for the entire western Po Plain (in the Piemonte region) attributing the lower density estimate (0.22 hawks/km^2) to the remaining 2500 km^2. Thus, we estimate a total wintering population of about 3700 (3200–4400) Common Buzzards. We suggest this is an underestimate because the lower densities, which are likely in some intensively-cultivated areas, should be overcompensated by a higher density of hawks along many riparian corridors.

The only other comparable Italian estimate is that of the wintering populations of the nearby region Lombardia provided by Fornasari et al. (1992); these authors, observing 246 Common Buzzards from 5731 points and assuming a detection distance of 200–500 m, estimated 1300–8000 birds over the whole region (23 850 km^2 including hills and mountains). Jointly, these results emphasize that the estimate of under 5000 wintering Common Buzzards (Chiavetta 1986) for the whole of Italy (301 302 km^2) was an underestimate.

Finally, we suggest that the distance transect method should be used for future raptor surveys to provide more rigorous comparisons of density and abundance estimates over large areas.

ACKNOWLEDGMENTS

We thank Sonia Canavelli for the helpful discussion, Maurizio Sarà and Luca Salvati for the bibliographical help, and Francesco Boano for assistance on figure preparation. Professor Steve Buckland kindly helped us understand the distance methods. Two anonymous referees and the editor greatly improved our manuscript.

LITERATURE CITED

ANDERSEN, D.E., G.J. HONGSTAD, AND W.R. MYTTON. 1985. Line transect analysis of raptor abundance along roads. *Wildl. Soc. Bull.* 13:533–539.

ANDERSON, D.R. AND K.P BURNHAM. 1999. Understanding information criteria for selection among capture-recapture or ring recovery models. *Bird Study* 46:14–21

BLOC, A. [ED.] 1987. La Buse variable. F.I.R., La Garenne Colombes, France.

BLONDEL, J. AND P. ISENMANN. 1981. Guide des oiseaux de Camargue. Delachaux et Niestlé Ed., Neuchatel, Switzerland.

BORDIGNON, L. 1998. Gli uccelli del Biellese. Collana Ambiente, Ass. Tutela Ambientale, Provincia di Biella, Italy.

BUCKLAND, S.T. 1987. On the variable circular plot method of estimating animal density. *Biometrics* 43:363–384.

———, D.R. ANDERSON, K.P. BURHNAM, AND J.L. LAAKE 1993. Distance sampling: estimating abundance of biological populations. Chapman and Hall, London, U.K.

BURNHAM, K.P., D.R. ANDERSON, AND J.L. LAAKE. 1981. Line transect estimation of bird population density using a Fourier series. *Stud. Avian Biol.* 6:466–482.

CANOVA, L. 1992. Poiana *Buteo buteo*. Pages 569–576 *in* P. Brichetti, P. De Franceschi, and N. Baccetti [EDS.], Fauna d'Italia, Aves I, Calderini Ed., Bologna, Italy.

CHIAVETTA, M. 1986. Main wintering areas of Falconiformes in Italy with some data on the species. *Suppl. Ric Biol. Selvaggina* 10:73–90.

CUCCO, M., L. LEVI, G. MAFFEI, AND C. PULCHER. 1996 Atlante degli uccelli di Piemonte e Valle d'Aosta in inverno (1986–1992). *Mus. Reg. Sci. Nat. Monogr.* 19· 1–395.

DEL HOYO, J., A. ELLIOTT, AND J. SARGATAL. 1994. Handbook of the birds of the world. Vol. 2. New world vultures to guineafowl. Lynx Ed., Barcelona, Spain.

FORNASARI, L., L. BOTTONI, R. MASSA, M. FASOLA, P. BRICHETTI, AND V. VIGORITA [EDS.]. 1992. Atlante degli uccelli svernanti in Lombardia. Regione Lombardia, Italy.

FULLER, M.R. AND J.A. MOSHER. 1981. Methods of detecting and counting raptors: a review. *Stud. Avian Biol.* 6: 235–246.

GLUTZ VON BLOTZHEIM, U.N. AND K.M. BAUER. 1980. Handbuch der Vogel Mitteleuropas. Vol. 4. Aula Verlag, Wiesbaden, Germany.

HAGEMEIJER, W.J.M. AND M.J. BLAIR. 1997. The EBCC atlas of European breeding birds. T. & A.D. Poyser Ed., London, U.K.

HALL, L.S., M.L. MORRISON, AND P.H. BLOOM. 1997. Population status of the endangered Hawaiian Hawk. *J. Raptor Res.* 31:11–15.

HINES, J.E. AND J.R. SAUER. 1989. Program CONTRAST. A general program for the analysis of several survival or recovery rate estimates. U.S. Fish Wildl. Serv. Fish Wildl. Tech. Rep. 24.

IPLA. 1982. La capacità d'uso dei suoli del Piemonte ai fini agricoli e forestali. Regione Piemonte, Italy.

MASSA, B. 1980. Ricerche sui rapaci in un'area campione della Sicilia. *Nat. Sicil.* 4:59–72.

MINGOZZI, T., G. BOANO, C. PULCHER, AND COLL. 1988. Atlante degli uccelli nidificanti in Piemonte e Val d'Aosta. *Monogr. Mus. Reg. Sci. Nat.* Torino, Italy.

MOSTINI, L. 1981. La Poiana *Buteo buteo* nella pianura novarese. Notizie sulle presenze ed abitudini. *Gli Uccelli d'Italia* 6:67–70.

REYNOLDS, R.T., J.M. SCOTT, AND R.A. NUSSBAUM. 1980. A variable circular-plot method for estimating bird numbers. *Condor* 82:309–313.

SARÀ, M. 1996. Wintering raptors in the central Mediterranean basin. Pages 345–359 *in* J. Muntaner and J Mayol [EDS.], Biologia y conservacion de las rapaces Mediterraneas, Actas VI Congr. Biol. Cons. Mediterranean raptors. Palma de Mallorca, Spain.

SCHROPFER, L. 1997. Winter census of birds of prey in the area located to west and south of Plzen city, determined by the line method. *Buteo* 9:17–30.

SUTHERLAND, W.J. 1996. Ecological census techniques. A handbook. Cambridge Univ. Press, Cambridge, U K.

THIOLLAY, J.-M. 1976. Les decomptes de rapaces le long des routes: essai de standardization. *Passer* 13:69–76

THOMAS, L., J.L. LAAKE, J.F. DERRY, S.T. BUCKLAND, D.L. BORCHERS, D.R. ANDERSON, K.P. BURNHAM, S. STRINDBERG, S.L. HEDLEY, M.L. BURT, F. MARQUES, J.H. POLLARD, AND R.M. FEWSTER. 1998. DISTANCE 3.5. Research Unit for Wildlife Population Assessment, Univ of St. Andrews, U.K.

TUCKER, G.M. AND M.F. HEATH. 1994. Birds in Europe Their conservation status. BirdLife International, Cambridge, U.K.

YEATMAN-BERTHELOT, D. 1991. Atlas des oiseaux de France en hiver. Soc. Ornithol. de France, Paris, France.

Received 30 December 2000; accepted 9 November 2001