POPULATION-DATA GAPS AND CONSERVATION PRIORITIES FOR UKRAINE'S INDIGENOUS LIVESTOCK BREEDS: AN ANALYSIS OF DAD-IS RECORDS

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Conservation planning requires evidence about both the condition of livestock populations and the coverage of the records used to assess them. This study compares Ukraine's country summaries in two FAO reports on the Domestic Animal Diversity Information System (DAD-IS) and interprets them using breed studies published by November 2022. Among the 68 breeds classified as local on 2 September 2022, 45 were at risk, 13 were not at risk and 10 had unknown status. The share at risk was 77.6% among the 58 breeds with a known classification. Holding those classifications fixed, the share at risk among all 68 breeds ranges from 66.2% to 80.9%, depending on the allocation of the 10 unknown cases. Since 3 February 2021, the number of local entries had risen from 62 to 68 while the number with known status had fallen from 60 to 58. Without linked breed records, the comparison cannot establish demographic recovery or decline. Field observations of Brown Carpathian cattle in 2019 show why an absence from breeding registers warrants follow-up with keepers. Genealogical evidence from Mirgorod pigs shows why surviving lineages matter when a major herd is lost. These examples support separate decisions about protection and verification. The first requires evidence of a threat to reproduction. The second identifies the missing observation most likely to change a conservation decision.

Key words: *animal genetic resources; Ukraine; DAD-IS; indigenous livestock; missing population data; conservation prioritization*

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1. Introduction

Ukraine's livestock diversity presents a conservation problem that cannot be resolved by counting breeds alone. A named breed may remain in an international database while its reproductive population contracts, its last organized breeding nucleus disappears, or its remaining animals become scattered among households. Conversely, a breed may cease to appear in an administrative register while animals belonging to it remain alive. These possibilities imply different interventions, even when all are described loosely as "loss." The central argument of this article is that population-data gaps are consequential features of conservation governance: they shape what can be recognized, funded, and rescued. However, uncertainty is not itself proof of demographic collapse. Effective conservation therefore requires an analytical distinction between evidence of biological vulnerability and the adequacy of the observation system through which vulnerability becomes visible.

The Domestic Animal Diversity Information System (DAD-IS) records information on breeds reported by participating countries. Two reports of the Food and Agriculture Organization of the United Nations (FAO) publish Ukraine's totals under the same three geographic groupings (FAO, 2021b, 2022). The tables allow readers to compare the distribution of reported classifications at two dates, even though they cannot see individual breed records. A separate question is what a classification implies for an actual herd. For that purpose the analysis uses breed studies with identifiable observation dates and sampling frames.

The distinction is apparent in the Ukrainian evidence. Voitenko et al. (2019) reported that registered Brown Carpathian cattle herds were no longer operating at the start of 2019. A field team nevertheless found animals with the characteristics of that breed in Transcarpathian villages during the following months (Polupan et al., 2020). The two studies observed different populations. A register of breeding establishments can document the loss of organized breeding capacity even when individual animals remain with keepers beyond its coverage. For conservation managers, the difference determines whom to contact and whether it may still be possible to arrange matings.

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Incomplete reporting affects the interpretation of change as well as the assessment of a single breed. When additional breeds enter an inventory, the percentage at risk can change even if the condition of every previously recorded population remains the same. A similar problem arises when a classification becomes unknown because its population count is too old. Comparing the total number of entries with the number that can be classified makes these changes in coverage visible.

The analysis asks how much of Ukraine's reported local-breed inventory had a known risk status at each date, how the unclassified entries affect the share at risk, and what further evidence a manager needs before acting on a particular breed. The quantitative comparison uses the published country totals. The case studies identify questions that those totals cannot answer, including where breeding animals remain and whether surviving animals represent more than one lineage.

2. Defining the populations and the information problem

"Indigenous" is used here as a conservation term for livestock populations with documented local historical development and distinctive genetic or cultural continuity in Ukrainian husbandry. This working definition includes locally developed breeds and less formally standardized heritage populations; longstanding residence alone does not qualify an imported commercial population. It does not assert that every included breed originated exclusively within present national borders, nor does it require an absence of historical crossbreeding. Traspov et al. (2016) documented complex ancestry among regional pig breeds, illustrating why ancestry and meaningful breed identity cannot be reduced to an opposition between pure origin and foreign influence. Inclusion is evaluated case by case, and no complete indigenous roster is enumerated here. The resulting scope identifies conservation resources through documented history and continuity rather than names or an exclusive-country-origin claim.

DAD-IS "local" is a different category. In the historical reporting framework, local breeds are those reported in only one country, while transboundary breeds occur in more than one country. That classification concerns reported geographic distribution and is not a direct measure of antiquity, adaptation, or cultural significance (FAO, 2022). A breed important to Ukraine can therefore fall outside the local category. The 2007 Global Databank annex, for example, placed Hutsul horses in a regional section and Ukrainian White Steppe pigs in an international section (FAO, 2007). Consequently, this article treats local-breed aggregates as an informative statistical subset, not as a complete indigenous-breed inventory. Conservation recommendations must include relevant transboundary populations through an explicit second step of evidence-based inclusion.

The distinction also applies to the geographical meaning of risk. The loss of a nationally important breeding population can be serious even where related populations remain elsewhere, because management knowledge, local lineages, and access to breeding material may not be interchangeable. Yet national contraction cannot automatically be described as global extinction. The appropriate unit of intervention may therefore be a Ukrainian national breed population, a particular breeding nucleus, or a network of connected households, depending on the evidence. Treating these units separately avoids both underestimating nationally consequential losses and exaggerating them into disappearance of the entire transboundary breed. It also clarifies why cross-border cooperation can be valuable without replacing the need to document and sustain populations within Ukraine.

Population information itself has several dimensions. A total headcount describes abundance, whereas numbers of breeding males and females describe reproductive structure; farm coverage describes the observation frame, and dates determine how current the observation is. An impressive total can coexist with very few effective breeding lines or heavy dependence on one establishment. Conversely, a modest population dispersed across independently managed herds may have options that a single-site total conceals. FAO's conservation guidance recognizes the importance of demographic and genetic structure in assessing vulnerability (FAO, 2013). For the present analysis, the practical implication is that data adequacy

cannot be represented by a binary distinction between “a number exists” and “no number exists.” It must be evaluated against the decision that the number is expected to support.

Unknown risk status is particularly easy to misinterpret. In these reports, it includes cases without population-size information and cases whose latest population observation is more than ten years old; it does not mean either that a breed is secure or that it is necessarily endangered. The at-risk grouping combines vulnerable, endangered, and critical categories, including the endangered-maintained and critical-maintained variants (FAO, 2021b, 2022). A previously recorded count can therefore coexist with present classification uncertainty, and a conservation programme does not automatically remove a breed from the at-risk grouping. The relevant objective is not maximum completion of a database form but population evidence that can discriminate among plausible actions. A major disruptive event can justify reassessment well before the ten-year reporting limit is reached.

Historical names create another source of uncertainty. Rieznykova (2022) reconstructed the distribution and husbandry of Polissian cattle from historical accounts, including a 1926 expedition survey. Such sources preserve information about the animals and places to which an old breed name referred. When reconciling reports, an inventory should retain the original spelling, the species and location, and the evidence for linking one name to another. A shared regional name alone is insufficient to establish a common population.

3. Materials and analytical methods

The study combines secondary analysis of FAO country tables with a targeted review of work on Ukrainian livestock breeds, recording practices and conservation decisions. The source set is limited to material published by 30 November 2022. The dates refer to the public availability of evidence. Observation dates and the coverage of a register, survey or sample are identified separately wherever the publications provide them. The review uses published records and includes no new census or interviews. The selection of illustrative cases does not establish how common each reporting problem was across Ukraine.

The principal quantitative sources are two FAO status-and-trends reports. The report entitled Status and trends of animal genetic resources–2020 was published in July 2021 and specifies a database reference date of 3 February 2021. The report entitled Status and trends of animal genetic resources–2022 was issued in November 2022 and specifies 2 September 2022. Ukraine’s rows in Annex 2, printed page 32 in each report, were transcribed and checked against the rendered tables (FAO, 2021b, 2022). These dates must be kept distinct from the observation years of individual population counts, which are unavailable in the extracted aggregates. The analysis therefore compares two published states of the reporting system, without assuming that all underlying livestock observations were collected on their respective snapshot dates.

For each snapshot, the extracted variables are counts classified as at risk, not at risk, and unknown, separately for local, regional transboundary, and international transboundary categories. The three categories of geographic distribution are retained throughout the calculations. The annexes exclude extinct breeds from the relevant risk summaries, so the denominator represents the recorded non-extinct inventory covered by those summaries rather than every historical breed entry. Arithmetic checks confirm that category totals equal the reported Ukraine totals. No record-level population export is available for linkage, and the aggregate table does not identify the breeds making up the unknown category. Consequently, neither breed-specific transition probabilities nor a species-specific missingness analysis can be derived from these data.

Let A denote the number classified at risk, S the number classified not at risk, and U the number with unknown status. The inventory denominator is $N = A + S + U$. Four complementary quantities are calculated: observed at-risk share A/N, unknown share U/N, classification coverage $(A + S)/N$, and at-risk share among classified breeds $A/(A + S)$. These quantities answer different questions. In particular, A/N measures the recorded burden across the full eligible inventory, whereas $A/(A + S)$ describes the composition of the classified subset. Reporting either alone would conceal information that the other supplies. Percentages

are therefore presented with their denominators, and differences between snapshots are expressed in percentage points rather than conflated with percentage changes in animal populations.

To examine the consequences of unknown status without imputing it, the analysis calculates an allocation range from A/N to (A + U)/N. The lower endpoint places every unknown case in the not-at-risk category; the upper endpoint places every unknown case in the at-risk category. This is an exact arithmetic sensitivity analysis conditional on the published inventory and the correctness of the known classifications. It is not a statistical confidence interval, a forecast, or a bound on all unregistered indigenous populations. The approach is deliberately modest because the aggregate data provide no basis for assigning probabilities to the unknown cases. Its value is to reveal which conclusions survive the entire possible allocation of the cases that the reporting system explicitly leaves unresolved.

Missingness is considered as a potentially informative process, rather than assumed to be random. Rubin's (1976) analysis shows that disregarding missing-data mechanisms requires particular assumptions; it does not justify inferring the mechanism from missing values alone. In this setting, institutional disruption, dispersed husbandry, and population decline could influence the likelihood of observation, but the available aggregates cannot identify their respective contributions. Accordingly, no missing-at-random model, multiple imputation procedure, or significance test is fitted. The defensible synthesis is to investigate plausible mechanisms through contextual evidence while retaining uncertainty in the numerical results. This separates an empirically supported reporting gap from untested explanations for why particular breed records are incomplete.

The case studies were selected for the distinct questions their sources can answer. For Brown Carpathian cattle, field observations can be compared with the register of breeding establishments. For Mirgorod pigs, genealogical records show which resources survived the loss of a major herd. For Ukrainian Steppe pigs, earlier registered sow counts provide a baseline for renewed enquiry. The Hutsul horse illustrates the distinction between a breeding population in Ukraine and a breed distributed across countries. These examples do not establish national frequencies, and none can be matched to an unidentified entry in the country totals.

4. Results of the historical DAD-IS analysis

The September 2022 summary reports 161 entries across Ukraine's three geographic categories: 68 local, 18 regional transboundary, and 75 international transboundary. Within the local group, 45 were at risk, 13 not at risk, and 10 unknown; the corresponding regional counts were 11, 2, and 5, and the international counts were 17, 48, and 10 (FAO, 2022, p. 32). These are counts of classified breed populations or entries, not numbers of animals. Table 1 preserves the original categories and shows the earlier snapshot alongside them. The distribution establishes a substantial recorded conservation burden, while leaving unresolved both the identity of unknown cases and the completeness of the broader indigenous inventory.

Table 1. Published risk classifications in Ukraine's DAD-IS country rows

Snapshot	Geographic class	At risk	Not at risk	Unknown	Total
2021	Local	47	13	2	62
2021	Regional	7	7	4	18
2021	International	4	60	9	73
2021	All classes	58	80	15	153
2022	Local	45	13	10	68
2022	Regional	11	2	5	18
2022	International	17	48	10	75
2022	All classes	73	63	25	161

Note. Snapshots: 3 February 2021 and 2 September 2022. Regional and international denote transboundary categories. Counts are entries, not animals; extinct breeds are excluded. All-class totals are sums of the three geographic categories. These country-row summaries are not interpreted as global extinction assessments of transboundary breeds. Sources: FAO (2021b, 2022), Annex 2, p. 32 in each report.

Among local breeds in September 2022, 58 of 68 had a known risk classification, giving 85.3% classification coverage. The 45 at-risk cases constitute 77.6% of the classified subset and 66.2% of the entire local denominator. These results are compatible rather than competing estimates: the former conditions on known status, while the latter retains the ten unknown cases in the inventory. Their joint interpretation is more informative than a single headline percentage. Even if every unknown case were subsequently classified as not at risk, the already recorded at-risk group would still represent approximately two-thirds of this inventory. The urgency of addressing documented vulnerability therefore does not depend on assuming that unknown cases are threatened.

Unknown status nevertheless creates meaningful decision uncertainty. The local allocation range is 66.2–80.9%, with a width of 14.7 percentage points, exactly equal to the unknown fraction. This range shows how much the reported at-risk share could change through resolution of existing unknown classifications alone, under the stated assumptions. It cannot capture errors in known classifications, omitted populations, or changes after September 2022. Those limitations prevent the upper endpoint from serving as an estimate of maximum actual national risk. Within the published inventory, however, the calculation provides a transparent argument for concurrent action: the known burden warrants conservation expenditure, while the unresolved portion warrants a separate information programme rather than silent assignment to either extreme.

The regional transboundary category displays a different balance. Its eleven known at-risk cases represent 84.6% of the thirteen classified cases, but five of eighteen cases remain unknown, producing 72.2% coverage. Its allocation range, 61.1–88.9%, is wider than the local range because uncertainty occupies a larger share of the denominator. The international category has 86.7% coverage, a known-status at-risk share of 26.2%, and an allocation range of 22.7–36.0%. These contrasts describe the published classifications, not inherent biological differences caused by geographic distribution. The small regional denominator and different compositions of the groups preclude a causal interpretation. They nevertheless show why all three groups should not be compressed into one undifferentiated conservation statistic.

Pooling the September 2022 categories produces 73 at-risk, 63 not-at-risk, and 25 unknown entries. The resulting at-risk proportion among the 136 classified entries is 53.7%, considerably lower than the local subset's 77.6%. This is a compositional effect: the international category contributes many not-at-risk entries. The pooled figure is arithmetically correct but answers a broader and different question from the one motivating indigenous-breed conservation. Its use as a headline could obscure the concentration of recorded vulnerability within locally restricted populations. The analytical implication is that denominator selection is a substantive conservation choice. An aggregate can be accurately calculated and still mislead if its population of reference is left unstated or does not match the policy question.

The earlier snapshot sharpens the distinction between reporting change and biological change. In February 2021, Ukraine's local category comprised 47 at-risk, 13 not-at-risk, and two unknown cases, for a total of 62 (FAO, 2021b, p. 32). By September 2022, the known-status at-risk percentage had declined from 78.3% to 77.6%, a difference of approximately 0.75 percentage points. During the same interval, unknown status rose from 3.2% to 14.7%, and coverage fell from 96.8% to 85.3%. Thus, an apparently favourable movement in the first percentage coincided with a substantial deterioration in classification completeness. Neither measure alone describes the change adequately, and the pair provides no basis for claiming population recovery.

Table 2. Classification coverage and sensitivity to unknown status

Snapshot / class	N	Coverage %	Unknown %	At risk among known %	Allocation range %
2021 / Local	62	96.8	3.2	78.3	75.8-79.0
2021 / Regional	18	77.8	22.2	50.0	38.9-61.1
2021 / International	73	87.7	12.3	6.2	5.5-17.8
2021 / All classes	153	90.2	9.8	42.0	37.9-47.7
2022 / Local	68	85.3	14.7	77.6	66.2-80.9
2022 / Regional	18	72.2	27.8	84.6	61.1-88.9
2022 / International	75	86.7	13.3	26.2	22.7-36.0
2022 / All classes	161	84.5	15.5	53.7	45.3-60.9

Note. Original calculations from Table 1. N = A + S + U; coverage = 100(A + S)/N; unknown = 100U/N; risk among known = 100A/(A + S). Allocation range = [100A/N, 100(A + U)/N], holding known classifications fixed. Ranges are not confidence intervals. Percentages are rounded to one decimal place.

The inventory itself also changed: the local denominator increased by six, the international denominator by two, and the regional denominator remained eighteen. These aggregate differences could reflect additions, removals, reclassification, changed data availability, or combinations of these processes. Without stable identifiers and linked breed histories, the reduction from 47 to 45 local at-risk entries cannot be interpreted as two recoveries. Nor can the increase from two to ten unknown entries be attributed entirely to previously classified breeds becoming undocumented. The required synthesis is a statement about the reporting system rather than an invented transition narrative: the later inventory contained more uncertainty, while the information available does not identify the record-level pathways through which that change occurred.

The sensitivity ranges provide a further result that remains robust to the explicit unknown cases. For local entries, the February 2021 range is 75.8–79.0%, compared with 66.2–80.9% in September 2022. Neither snapshot has a higher at-risk share under every allocation of unknown cases; changing inventories separately preclude a biological interpretation. In the later snapshot, the local lower endpoint exceeds the international upper endpoint by approximately 30.2 percentage points. Subject to the fixed recorded inventory and accepted known classifications, unknown-case allocation alone cannot remove that contrast. This is stronger than simply comparing complete-case percentages, although it remains a descriptive comparison. It establishes a difference within the published data, without claiming that geographic class causes risk or that the classes represent comparable biological populations.

The 2007 annex lists Ukrainian Grey and Ukrainian Whiteheaded cattle as critical, Mirgorod pigs and Ukrainian Grey ducks as endangered-maintained, and no population data for Carpathian Mountain sheep or Novoalexandrivska Cart horses (FAO, 2007, pp. 117–119). Gaps in the coverage of several species are therefore visible well before the two snapshots analysed here. The historical labels cannot be used as a series extending to 2022. Individual records are unlinked, and the later report describes a change in the classification methodology applied from 2018 (FAO, 2022).

5. Breed evidence and the limits of administrative visibility

Brown Carpathian cattle illustrate how the choice of observation unit affects an assessment. In February–June 2019, a field team examined 265 cattle phenotypically identified as Brown Carpathian in 31 villages across five districts of Transcarpathia. The sample included six bulls of breeding age (Polupan et al., 2020). In contrast, a study of the state breeding register found no functioning registered herd of the breed at the start of that year (Voitenko et al., 2019). The cattle observed in villages provide dated

evidence of a resource outside the formal breeding-herd count. The sample cannot establish the total number in Ukraine, the ancestry of each animal, or how many remained available for breeding after the visits.

The surveyed villages offer a starting point for a follow-up inventory. A repeat visit could record whether previously identified animals were still present, whether cows had produced replacements, and which bulls or semen had been available for mating. Extending enquiries through keepers would allow investigators to identify other holdings beyond the original sample. Recording previously visited and newly located holdings separately would make it possible to distinguish changes in the survey's coverage from changes within a known group of animals.

Mirgorod pigs illustrate a different distinction: the destruction of a major conservation nucleus does not necessarily eliminate every surviving lineage. Oger et al. (2019) described the loss of the principal gene-pool herd following African swine fever, whereas Tsybenko and Vashchenko (2020) subsequently documented surviving or recoverable genealogical resources and a severe contraction in population and family structure. The later evidence prevents the earlier account from being carried forward as an unqualified extinction statement. At the same time, survival of a few lines should not be presented as successful recovery. The conservation question is whether the surviving animals and stored material can support a viable breeding programme that retains meaningful diversity. That requires genealogical reconstruction and verified reproduction, not merely the continued appearance of the breed name.

A recovery programme can increase headcount while failing to recover lost representation. If a small number of surviving males produce most replacements, demographic growth may coexist with narrowing ancestry; if unrelated survivors are overlooked, their value may be lost before the programme recognizes them. These are plausible management risks, not measured outcomes assigned here to particular Mirgorod herds. They imply that recovery monitoring should track contributions of founder lines and sow families alongside animal totals. The practical synthesis is to define success before expanding the population: retain identifiable diversity, distribute reproductive contributions where feasible, and verify that stored genetic resources correspond to the gaps in the living population. Numerical growth becomes meaningful when it is linked to these explicit conservation objectives.

The register also provides a dated baseline for two Ukrainian Steppe pig breeds. Between 2011 and the beginning of 2019, recorded sow numbers fell from 764 to 159 for Ukrainian Steppe White and from 48 to 25 for Ukrainian Steppe Spotted (Voitenko et al., 2019, Table 3). These are counts in breeding establishments. The relative size of the two populations and the contraction in each are relevant to planning a follow-up, but their later condition cannot be read from the earlier entries. A new enquiry should establish which holdings still keep breeding females, whether boars or semen are available and how completely those holdings cover the breed. These observations would determine which conservation actions remain feasible.

Hutsul horses show why the geographic boundary of a conservation decision must remain explicit. Starodub et al. (2020) describe the breed as an aboriginal resource of the Ukrainian Carpathians, document contraction in the registered breeding sector, and identify two establishments retaining breeding status. This differs from the absence reported by Voitenko et al. (2019); the publications' dates and observation frames cannot be linked to establish a restoration of breeding status. The breed also exists beyond Ukraine, making international survival and national continuity separate questions. Foreign populations may offer opportunities for coordinated breeding without replacing Ukrainian lineages, keeper knowledge, or locally established use. Priority assessment should therefore examine Ukraine's reproductive network and its relationships with other populations, using cross-border collaboration to support national continuity.

For Grey Ukrainian and Whiteheaded Ukrainian cattle, conservation value extends beyond survival statistics. Rieznykova et al. (2018) analyzed longevity and reproductive characteristics in specified herds, providing evidence that traits relevant to sustained husbandry merit attention alongside output per

lactation or growth period. Their retrospective samples and herd conditions do not establish universal superiority over commercial breeds, and the reported study animals are not a national census. The justified inference is that conservation decisions should preserve the possibility of evaluating and using such traits under appropriate conditions. Practical prioritization can recognize this option value while demanding stronger comparative evidence before making broad claims about resilience, disease resistance, or economic advantage across production systems.

Genetic characterization adds information that demographic reporting cannot supply, but it does not repair a missing census. Kramarenko et al. (2018) examined microsatellite variation in 350 pigs drawn from five Ukrainian local breeds and Duroc, documenting variation within and among the sampled groups. Such studies support attention to genetic representation, while their samples remain limited by selection, location, and marker design. A count of genotyped animals must never be substituted for the number alive, and a differentiated genetic cluster is not automatically an estimate of adaptation or conservation urgency. The useful synthesis is complementary: demographic surveys establish where reproductive populations remain, while appropriately designed genetic work helps identify how their diversity should be retained.

Sheep and poultry expose a further danger of relying on the visibility of a few well-studied cattle and pig breeds. The historical annex contains both unreported population entries and threatened poultry entries, while the national literature includes breeds whose administrative histories require further reconciliation (FAO, 2007; Vishnevsky, 2017). The available evidence does not support a current species-wide ranking or a declaration that a particular unobserved sheep or poultry population has disappeared. It does support including these groups explicitly in the next inventory. Otherwise, conservation attention may follow the density of existing publications rather than the distribution of unmet need, leaving poorly documented populations excluded precisely because they are difficult to observe.

Across these cases, four different outcomes must remain separate: loss of a reporting unit, decline of a reproductive population, loss of genetic representation, and extinction. Each can occur without perfect correspondence to the others. The cases are selected illustrations and cannot reveal how frequently each outcome occurs nationally, but they demonstrate that a single “present/absent” field is insufficient for conservation management. A national evidence record should therefore allow these dimensions to be described independently and revised when new information appears. This design preserves the seriousness of verified losses while keeping open the practical possibility of finding survivors, reconnecting keepers, or recovering lineages through material already held in conservation facilities.

6. Conservation priorities under incomplete information

The evidence supports two connected but distinct decisions: which populations need immediate protection, and which uncertainties need urgent resolution. Assigning every unknown breed the highest biological risk would confuse information scarcity with demonstrated vulnerability. Assigning unknown breeds low priority would create the opposite error by making lack of observation a reason for neglect. The proposed framework therefore maintains a conservation priority and an information priority for each identified population. These are decision categories rather than measured probabilities or a new FAO classification. Their purpose is to ensure that a well-documented threatened herd can receive protection while a poorly documented population receives a targeted search, with emergency support available when field evidence reveals an immediate threat.

For conservation action, the first criterion should be a verified threat to reproductive continuity. Relevant evidence includes very small numbers of breeding animals, loss of accessible mating partners, collapse of an essential nucleus, or dependence on one location exposed to a major hazard. However, a low headcount alone does not describe all the genetic and demographic processes involved. Gandini et al. (2004) distinguish criteria relevant to assessing endangerment, supporting a broader evaluation than total abundance. The operational

conclusion is to collect enough reproductive and spatial information to identify the mechanism of vulnerability. Protection can then address that mechanism through husbandry support, breeding coordination, population duplication, or genetic-resource collection, rather than relying on a label that leaves the required action unspecified.

Information priority should instead depend on the consequences of uncertainty and the likelihood that new evidence will alter a decision. A long reporting gap in a dispersed population may justify a survey, while uncertainty about the location of a sole breeding nucleus may require immediate contact and verification. These judgments cannot be converted into a credible numerical score from the country aggregates available here. They can be expressed as documented decision rules: identify the missing fact, explain the action it could change, specify a feasible verification route, and set a review point. This makes uncertainty actionable without pretending it has been statistically measured. It also prevents expensive data collection from becoming an end in itself when the immediate conservation decision is already clear.

Conservation value provides a further dimension, because limited resources cannot be allocated solely by demographic risk. Simianer et al. (2003) formalized allocation in relation to extinction risk, diversity, and the effects of conservation expenditure; Simianer (2005) emphasized the need to consider both within-breed and between-breed diversity and recognized breed values. These approaches are useful conceptual guides, but their application requires inputs that the Ukrainian aggregate summaries do not supply. An apparently precise optimization based on invented costs or extinction probabilities would therefore be less defensible than a transparent qualitative decision. The recommended approach is to articulate the objectives and document the available evidence, reserving quantitative optimization for a later stage when its assumptions and inputs can be examined.

Immediate protection and long-term sustainable use should be designed together. Keeping endangered animals alive can prevent an irreversible loss, but maintenance without a reproductive plan or a viable keeper network may postpone rather than resolve the problem. Conversely, requiring short-term commercial profitability before providing emergency support can eliminate populations whose future contribution is uncertain but potentially valuable. The synthesis is a staged commitment: stabilize the identifiable reproductive resource, establish a breeding and recording arrangement, and then assess sustainable uses under realistic local conditions. Emergency decisions need not wait for a complete business model, while continuing support should have explicit milestones beyond the purchase or relocation of animals.

Cryoconservation is essential to this strategy when it preserves material that can actually serve an identified conservation objective. FAO (2012) distinguishes collection management and the adequacy of stored material for future use, making clear why the existence of a freezer or a quantity of semen is insufficient evidence of security. Donor representation, material type, quality, records, and practical accessibility all matter. Nevertheless, missing public documentation does not establish that material is absent: Leroy et al. (2019) found discrepancies between institutional collections and DAD-IS information in a survey that included Ukraine. The appropriate priority is therefore an inventory and adequacy audit of relevant holdings, followed by targeted collection to address documented gaps rather than unsupported claims that breeds are already secured or entirely unrepresented.

The relationship between living populations and stored material should be assessed at the lineage level where feasible. A collection can be valuable because it contains ancestry now rare in living herds, while a large collection from closely related donors may offer less additional representation than its size suggests. These are reasons to link records, not grounds for assuming that a particular Ukrainian collection is inadequate. The proposed audit should identify which living and stored resources overlap, which complement one another, and which lack sufficient documentation for use. A conservation plan can then prioritize collection, regeneration, or managed mating according to the actual gap. This approach treats the genebank as part of the

reproductive system instead of a separate institution whose holdings are counted without reference to management needs.

Geographic duplication can reduce dependence on a single holding, but it also introduces coordination costs and possible changes in husbandry conditions. Moving animals or material without maintaining identity, health documentation, and breeding plans may weaken rather than strengthen conservation. The decision should therefore compare the benefit of reducing common exposure with the practical risks of maintaining multiple sites. Where duplication is appropriate, responsibilities and exchange arrangements should be specified before the populations diverge administratively. The aim is not to scatter a breed indiscriminately but to establish connected, identifiable populations that can support one another. This is especially relevant when a major nucleus has disproportionate importance for both the animals and the records through which the breed is managed.

Keeper participation is a condition of continuity, particularly where household populations provide the remaining conservation resource. A recording system that imposes costs without benefits may discourage participation and reproduce the very invisibility it is intended to solve. At the same time, support based solely on self-declared breed ownership can create unreliable records and uneven eligibility. A workable arrangement should combine accessible registration, documented identity assessment, useful breeding advice, and clearly defined support. Participation can then improve both conservation and data quality. The underlying principle is reciprocal responsibility: keepers contribute reliable observations and agreed management, while institutions provide services that make continued participation practical rather than treating households merely as data suppliers.

Table 3 translates these principles into a provisional action agenda for the populations discussed. It identifies the first evidence needed and a corresponding test of progress, rather than assigning unsupported numerical scores. Priorities remain conditional on verification of the historical evidence at the point of implementation. For example, a search that confirms surviving animals should lead to protection and breeding coordination, while confirmation that only stored material remains would require a different recovery assessment. The agenda makes this dependence explicit: each recommendation is connected to an observable question, and its success is defined by a change in knowledge or reproductive security that can be checked.

Table 3. Proposed population-specific action agenda

Population	First unresolved question	Proposed first action	Evidence of progress
Brown Carpathian cattle	Which holdings still keep breeding animals, and which sire lines are available to them?	Revisit the villages covered in 2019 and trace other holdings through keepers.	Dated records of breeding females, available sires and recent matings.
Mirgorod pigs	Which surviving lines and stored donors can contribute to recovery?	Reconcile living-animal genealogies with usable germplasm holdings.	Verified founder representation and a feasible mating plan.
Ukrainian Steppe White and Steppe Spotted pigs	What breeding resources remain at or beyond the holdings represented in the 2019 sow counts?	Trace the registry holdings and verify living breeding stock and usable stored material for each breed.	Dated counts by breed and holding, with gaps in survey coverage recorded.
Grey Ukrainian and Whiteheaded Ukrainian cattle	How current are counts of breeding animals and connected holdings?	Update reproductive censuses and assess dependence on individual holdings.	Traceable coverage, breeding-sex counts, and a continuity plan.
Hutsul horses in Ukraine	What explains the discordant administrative accounts, and which reproductive network remains?	Reconcile registrations, holdings, and genealogies; coordinate with relevant transboundary partners.	A dated national inventory linked to recognized breeding relationships.
Poorly documented sheep and poultry populations	Which historical identities correspond to living populations?	Reconcile names and locate keepers before assigning current status.	Verified identities and observations, with unresolved cases retained explicitly.

Note. These actions follow from the dated evidence reviewed in Sections 5 and 6. The final column specifies what a future survey or conservation programme could verify.

7. A reproducible programme for closing the gaps

The first implementation task is an authoritative breed and population register that can be reconciled with DAD-IS. Each entry should retain a stable identifier, species, accepted name, alternative names, geographic class, and the evidence supporting its inclusion in the indigenous conservation scope. Existing administrative names should remain traceable even when they are superseded. However, creating a comprehensive list is not equivalent to demonstrating that all listed populations are alive or reproductively viable. The register should therefore distinguish historical recognition from verified contemporary presence and from unresolved status. This simple separation would allow new discoveries and documented losses to be incorporated without silently changing the meaning of earlier records or inflating the apparent number of successfully conserved breeds.

Every population observation should then be stored with its own date and provenance. The date animals were counted, the date the information was submitted, and the date a database snapshot was published are different events. FAO's detailed analysis of DAD-IS reporting distinguishes updating activity from other dimensions of information completeness (FAO, 2021a). A newly edited record may therefore contain an old observation, while an unchanged record may refer to a population that continues to exist but has not been revisited. The proposed reporting system should expose these distinctions directly. A conservation analyst could then assess recency without mistaking administrative activity for field monitoring, and a later reviewer could reconstruct what was actually known at a specified historical cutoff.

The minimum demographic record should include total animals, breeding females, breeding males, the number of holdings covered, and the relationship between the covered holdings and the intended population. These fields should be accompanied by the count method and explicit uncertainty where enumeration is incomplete. A single precise-looking total is less informative than a bounded

estimate with a documented frame when households or inaccessible holdings are omitted. FAO's surveying guidance provides a basis for matching inventory methods to the population and purpose (FAO, 2011). The operational requirement is to prevent a subset from being silently promoted into a national census. Registered breeding animals, surveyed household animals, and inferred totals should remain separately identifiable even when they appear in a common reporting system.

Missing values require a controlled vocabulary. "Not collected," "temporarily inaccessible," "not applicable," "awaiting verification," and "confirmed zero" should not share an indistinguishable blank cell. Yet the system should avoid making field collection so elaborate that essential observations are delayed. A small number of well-defined categories, supported by a short explanatory note when necessary, would capture the distinctions most likely to affect decisions. In particular, a confirmed zero must specify the scope searched and the date of verification. This would prevent a missing response from becoming an apparent extinction event and prevent a zero within one establishment from being misread as a zero across the entire breed population.

Field verification should combine a stable panel of known holdings with targeted searches beyond the panel. Repeated observations from the same holdings support interpretation of change, while searches through local veterinary services, breeder networks, and household contacts can identify populations outside formal registers. Neither component alone is sufficient: a panel may progressively lose coverage, while repeated opportunistic searches may not provide a comparable time series. Their combination allows monitoring and discovery to serve different purposes. Any newly located population should enter the register with a clear source and confidence assessment, and any panel loss should trigger investigation rather than automatic deletion. This would make changes in the observation frame visible alongside changes in the animals observed.

Monitoring frequency should reflect the decision horizon of the population concerned. A stable and widely distributed population may not require the same contact intensity as a very small nucleus undergoing disruption. However, the urgency of contact should not be mistaken for a universal biological threshold or an inference that every uncontacted population is deteriorating. The programme should specify why a population is reviewed more frequently and what event triggers additional verification. Examples include loss of a breeding male, closure of a participating holding, interruption of a collection facility, or evidence that the available records no longer cover the population. Review schedules then become part of risk management, with a documented rationale that can be revised as conditions change.

An integrated germplasm register should link each collection to donor identities, collection dates, material types, storage locations, quality information, and access arrangements. Summary counts can be useful for oversight, but they cannot establish reconstructive capacity without the associated biological and operational information. The register should therefore record what each collection is intended to achieve: support an existing population, preserve rare lineages, or contribute to possible reconstitution. Material whose identity or viability is uncertain should remain visible as a resource requiring verification. This prevents two wasteful responses, unnecessary collection of already well-represented material and overconfidence in holdings that cannot yet be used reliably for the intended conservation purpose.

Public transparency should be designed around the information needed for accountability. Breed-level totals, methods, observation dates, uncertainty categories, and broad geographic coverage can support external assessment. Precise locations of vulnerable holdings and personally identifiable keeper information may require restricted access, especially under conditions of disruption. These considerations need not obstruct scientific reproducibility: a public analysis can use appropriately aggregated data while an authorized operational register retains the detail needed for action. The essential requirement is a documented relationship between the public statistics and the protected source records. This preserves the possibility of checking calculations without making the availability of

sensitive detail a precondition for acknowledging the existence of a population.

Performance measurement should separate better reporting from better conservation outcomes. Increasing the fraction of records with known status is an information achievement, but it could coincide with the discovery that more breeds are threatened. Conversely, a declining at-risk percentage could be produced by additions of well-documented commercial populations or by movement of threatened entries into unknown status. The results of this article demonstrate why such possibilities cannot be ignored. A national dashboard should therefore report inventory membership, coverage, recent observations, and reproductive outcomes together. The aim is to reward accurate recognition and effective action, rather than encourage institutions to improve a headline indicator by changing which populations are counted or leaving difficult cases unresolved.

Funding should support continuity of observation as well as discrete rescue projects. Surveys that identify surviving animals have limited value if no institution maintains contact, updates identities, or records subsequent reproduction. Yet permanent monitoring expenditure also requires accountability and should be proportional to what it enables. A practical funding agreement can specify a manageable set of outputs: verified holdings, current breeding-animal counts, documented changes in coverage, and actions taken when agreed triggers occur. This connects reporting resources to concrete conservation decisions. It also allows programme evaluation to ask whether new information changed management, rather than treating the production of a database entry or a report as sufficient evidence that a population has become safer.

8. Discussion and limitations

The strongest quantitative conclusion is that documented vulnerability and information gaps coexist. The recorded local-breed burden remains substantial even under the most favourable allocation of unknown cases, while increased uncertainty weakens the interpretation of changes between snapshots. This result supports immediate conservation of identifiable threatened populations alongside targeted verification of unresolved ones. It does not support the claim that Ukraine's entire indigenous livestock inventory has been measured, because local and indigenous are not equivalent categories. The contribution lies in making the scope of the evidence explicit. A country aggregate can guide the scale and direction of attention while leaving the selection of particular interventions dependent on breed- and holding-level verification.

The study also identifies an important limit to threshold-based reasoning. Standardized risk categories make reporting tractable, but they summarize complex demographic and management conditions. Hilton et al. (2022) emphasize that conservation thresholds depend on their purposes and the decisions they are meant to support. Applying a category outside that context can create unwarranted certainty, particularly where observations are outdated or incomplete. The appropriate response is not to abandon standardized classification but to preserve the underlying evidence and distinguish the classification from the action decision. A breed can require an urgent information response without a revised formal category, and an existing threatened population can warrant support before every desirable field has been completed.

Publication date, database reference date and date of observation differ across the sources. The November 2022 FAO report describes classifications as of 2 September, but its country table does not give the age of each underlying count. The village survey for Brown Carpathian cattle took place in 2019. Its results cannot establish how many animals remained at the time of the September snapshot. A direct comparison of population sizes would require dated, linked breed records and a description of the holdings reached at each observation.

Selection and measurement limitations also remain. The country summaries contain only populations recognized within their reporting framework, while the literature synthesis favours breeds for which accessible studies exist. Neither can reveal the full extent of unregistered diversity, and no inference about the absence of a breed follows solely from its absence in the selected literature. Moreover, the allocation ranges assume that known risk classifications are correct; they do not

incorporate misidentification, inaccurate counts, or incomplete within-breed coverage. These limitations prevent a comprehensive estimate of extinction risk. They also specify the most useful next research: validate the inventory frame, link individual records across dates, and investigate whether the populations least visible administratively are also those least supported institutionally.

The September 2022 database summary also cannot isolate an effect of the war. It contains no breed-level dates of last observation, measure of exposure, or information on changes in access to individual holdings. A newly unknown classification could reflect an old count passing the reporting time limit, a revision to the inventory or other changes in what was reported. Distinguishing these explanations would require the histories of the individual records. Managers can still respond to a threat verified at a particular holding without attributing a change in a national percentage to that same event.

Finally, the priority framework is a proposal for disciplined decision-making, not a validated prediction model. Its emphasis on reproductive continuity, information consequences, genetic representation, and keeper participation follows from the combined evidence, but its effectiveness must be evaluated in implementation. The framework should be revised if field experience shows that its decision categories overlook important populations or create excessive reporting burdens. A useful evaluation would examine whether it finds previously invisible survivors, prevents avoidable losses, and improves the traceability of conservation decisions. These outcomes would provide a stronger test of value than the production of a more elaborate ranking whose apparent precision exceeds the quality of the information from which it was constructed.

9. Conclusion

The historical DAD-IS summaries support a clear but bounded conclusion. Ukraine's recorded local breeds faced a high burden of classified risk in September 2022, and the increase in unknown status since February 2021 substantially reduced the completeness of that assessment. The small decline in risk among classified entries cannot be interpreted as recovery because the inventory changed and individual transitions are unavailable. The contribution of the analysis is therefore not a retrospective census or an extinction forecast. It is a reproducible demonstration that the numerator, the denominator, and the unresolved cases must be considered together before a statistical indicator is used to set conservation priorities.

The breed studies illustrate different uses of verification. Where a formal herd has ceased operating, the Brown Carpathian field observations give investigators places and keepers from which to start a new inventory. For Mirgorod pigs, the loss of the principal herd makes the representation of surviving lineages central to a recovery plan. The earlier sow counts for the two Steppe pig breeds identify a further need for follow-up, while leaving their subsequent status unresolved. Each decision asks for information that could change a specific action, such as protecting a breeding group, arranging a mating or tracing a donor.

For Ukraine's indigenous livestock, the priority is thus a durable relationship between animals, keepers, institutions, and evidence. A reliable count is valuable when it identifies a population that can be supported; a conservation intervention is accountable when its effects can be observed and its assumptions examined. The proposed framework translates this relationship into separate but linked decisions about protection and verification. Its value remains conditional on sustained implementation, inclusive population coverage, and transparent revision. These conditions provide a practical foundation for conserving diversity under uncertainty without claiming more than the historical record can establish.

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Прогалини в даних про чисельність і пріоритети збереження аборигенних порід сільськогосподарських тварин України: аналіз записів DAD-IS

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Для планування збереження порід потрібні дані як про стан популяцій сільськогосподарських тварин, так і про повноту їх обліку. У дослідженні зіставлено зведені дані щодо України з двох звітів ФАО про Інформаційну систему з різноманіття свійських тварин (DAD-IS). Результати розглянуто з урахуванням досліджень окремих порід, опублікованих до кінця листопада 2022 року. Станом на 2 вересня 2022 року серед 68 порід, віднесених до місцевих, 45 перебували під загрозою зникнення, 13 — поза загрозою, а статус 10 залишався невідомим. Серед 58 порід із визначеним статусом частка порід під загрозою становила 77,6 %. Якщо залишити відомі статуси незмінними, частка порід під загрозою серед усіх 68 становитиме від 66,2 до 80,9 % залежно від того, як розподілити 10 невизначених випадків. Порівняно з 3 лютого 2021 року кількість облікованих місцевих порід зросла з 62 до 68, тоді як кількість порід із визначеним статусом зменшилася з 60 до 58. За відсутності можливості зіставити записи про кожну породу за обидві дати ці дані не дають змоги встановити, чи відновлювалися популяції, чи скорочувалися. Польові спостереження за худобою бурої карпатської породи у 2019 році показують, чому відсутність племінного стада в реєстрі потребує перевірки безпосередньо в господарствах власників тварин. Генеалогічні дані щодо миргородської породи свиней засвідчують важливість уцілілих ліній після втрати основного стада. Ці приклади дають підстави окремо визначати потребу в охороні та потребу в перевірці даних. Перше рішення потребує доказів загрози відтворенню популяції. Для другого слід визначити, яких саме спостережень бракує і які з них можуть змінити вибір заходів зі збереження.

Ключові слова: *генетичні ресурси тварин; Україна; DAD-IS; аборигенні породи сільськогосподарських тварин; брак даних про чисельність популяцій; визначення пріоритетів збереження*