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Auditing an Academic Library Book Collection

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by Jack E. Kiger and Kenneth Wise

. **Librarians may use attribute sampling to estimate the maximum portion of a population having an attribute of interest. Advantages of the technique are that the user may examine a very small portion of the population and make an estimate with very low but measurable risk of misstatement.**

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Auditing academic library book collections is a subject discussed infrequently in library literature, and where it is mentioned, the reference is usually to inventorying for some specific aspect of financial valuation. Audits have been made of collections for purposes of insurance valuation, tax appraisal, capital asset documentation, and capital depreciation for university accounting.[1] While these audits are appropriate, they are just a few of the uses available to collection management.

The purpose of an audit, whether administered internally or externally, is to gain confidence that the resources are being responsibly managed and to ensure effective control over financial and material resources.[2] Effective managerial control over library materials involves much more than being able to evaluate the monetary worth of the collection, or knowing the percentage of books missing from holdings. Useful categories of information significant to collection management include the (1) occurrence of titles incorrectly cataloged, (2) percentage of books improperly barcoded, (3) number of items needing repair or preservation, or (4) portion of titles in a specified subject area that circulate above a certain rate.

Recently auditors from the Audit Division of the state of Tennessee cited the University of Tennessee for failure to take regular physical inventories of the Library's book holdings. As a result of the state's recommendation, the Library was charged with conducting an audit of the collection to determine the percentage of books missing from the collection. Although the state's charge was limited to determining the percentage of missing books, the library's collection development officer suggested that the scope of the audit be expanded to include gathering information useful for collection management. This entailed designing an audit not only to determine the number of books missing from the shelves, but also evaluating the accuracy of the bibliographical control of the collection. That required verifying the individual elements that identify the relationship between the catalog records and the items on the shelf.

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Librarians have applied an assortment of analytical and statistical methodologies to a variety of collection management problems, including for example, sampling to determine the quality of the online catalog,[3] sampling the cataloging backlog to identify materials needing immediate attention,[4] and sampling the collection before incurring additional reconversion expenses.[5] This article illustrates how academic and research libraries might apply attribute sampling techniques to auditing principles to determine specifically prescribed information about the collection and the catalog. Through attribute sampling librarians can make mathematically quantifiable inferences about specific characteristics of the collection or catalog by examining only a small portion of the holdings. Accordingly, attribute sampling can be a useful tool for clarifying cataloging and access problems, evaluating allocation strategies, and making collection development decisions.

NATURE OF THE AUDIT

An academic library's collection, generally the books, journals, documents and other published materials that make up the holdings, is the locally held information inventory to which a library user demands access. The collection at the University of Tennessee, like that of most academic research institutions, consists of large numbers of unique titles housed on shelves and arranged according to a classification system such as the Library of Congress. This arrangement requires a one-to-one relationship between the individual collection item and its corresponding inventory record. Actual access to the collection is made possible by the catalog record, a computer file containing certain bibliographic and location data for each item in the collection.

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The library's ability to make information accessible to the user can be impaired when either (1) an item is missing from the shelf or (2) the catalog record omits or inaccurately reflects an item. Often the catalog contains the only recorded information indicating the existence and location of a particular item in that library's collection. Thus, the records about the collection are as significant as the collection itself to the extent that the library's objective is to provide access to information.

In satisfying the state's recommendation, the primary objective of the library's audit was to verify the existence of the book materials. Given the relationship between the book collection and the catalog, the audit necessarily entailed a verification of the accuracy of the catalog record. The scope of the audit, thus, included an examination of both the collection and the catalog. This suggests two distinct but interconnected questions. First, to what extent does the collection match the item records in the catalog? And second, to what extent do the catalog records reflect the actual holdings on the shelves? The first question attempts to examine the completeness of the collec-

tion: "Does each item reflected in the catalog exist?" The second question pertains to both the accuracy and the completeness of the catalog record, that is, "Is each item in the collection properly reflected in the catalog record?"

The University of Tennessee Library maintains a collection of two million volumes housed in a main building and five branch units. Bibliographic records for most of the collection are maintained in a catalog database, part of the Library's Online Library Information System (OLIS). For purposes of satisfying the state recommendation, only those items represented by a record in the OLIS catalog were inventoried. Given the size of the population and the time and expense of examining all items, we chose to use attribute sampling techniques which allowed us to examine a very small portion of the items.

Attribute sampling enables one to make an estimate of a maximum occurrence rate, such as the maximum portion of books shown in the records as being on the shelf that are actually not on the shelf. In addition to making an estimate, attribute sampling techniques result in one's being able to state a confidence level about the estimate.

THE CATALOG-TO-COLLECTION TEST

The primary objective of a catalog-to-collection test was to gather evidence about the maximum percentage of items in the catalog that was missing or otherwise unlocatable. This is the first step in using attribute sampling as presented in the Appendix to this article. The population consisted of all items listed in the catalog. Each record in the catalog was a sampling unit. (Step 2) If an item in the catalog record could not be located, then that item was missing, and, for audit purposes, a deviation had occurred.

Considering the resources available to perform the audit, the general purpose of the collection, its accessibility to the public, and the general profile of the users, the collection development officer determined that she would be comfortable with the records if we could test a sample of records and conclude that no more than five percent of the records were in error (step 3) and with a 10 percent risk of concluding that the deviation rate was lower than it actually was (Step 4). Based on her knowledge of the collection, the collection development officer estimated an expected deviation rate of 3.5 percent.

Using a lower risk would have caused the sample size to be larger. Using a higher maximum deviation rate would have caused the sample size to be smaller. Also, had the expected deviation rate been higher, the required sample size would have been larger. Using a table to determine sample size, we determined the required sample size to be 400 titles.

Sampling the Catalog Record

Individual catalog records are the sampling units or the items to be selected in the sampling process. Drawing the sample was a straight-forward task of applying a random generator routine to the catalog records for those items located in the main library collection. The record for each sample item included the call number, main entry (title), author, and barcode number. The call number, a unique identifier assigned to each item to designate where that item is to be placed in the collection, is affixed to the item and is part of the catalog record. The barcode number, a unique number sequence used as a circulation control, links each item with its catalog record. The barcode, like the call number, is affixed to the book. For call numbers representing multiple copies of an item, the procedures included accounting for all copies of the number selected for the sample.

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In some academic libraries, certain materials such as journals may be represented in the catalog by a single entry under the journal title rather than by an entry for each bound volume or individual issue. Items of this nature would be statistically under-represented in a sample drawn from the catalog. Usually, however, entries of this type will be referenced to a separate subsidiary check-in or inventory file listing the volume/issues received by the library under that title. To insure that these items have an equal chance of being selected, the subsidiary check-in file can be appended to the catalog for purposes of drawing the sample.

Materials Currently in Use

Because in-house users are constantly taking materials off the shelves, items may appear to be missing that are not. Materials being used in-house should return to the shelves within a reasonable period of time and, thus, would be located in a follow-up procedure which can be undertaken whenever the routine reshelving has been completed. Materials on loan to external borrowers may not, depending on the type of loan, return to the shelves within the immediate future.

Materials on loan to borrowers generally will be checked out to the individual borrower through the library's circulation system. The circulation system operates as a separate inventory system, matching a book item with its borrower. Circulation systems can be either manual or online, but in both cases the access points for the circulation system will be the same as those for the catalog. In other words, an item should be retrievable in the circulation system by the main entry just as it is in the catalog.

In the Library's OLIS, the catalog record indicates if an item is "on loan" through the circulation module. Therefore, we could determine whether an item was on loan at the time the sample was being selected. Being informed by the circulation system that an item is "on loan" is not the same as knowing that the item exists. The circulation system may be inaccurate. Two means of gaining assurance about the "on loan" items are: (1) to issue a recall notice for each sample item identified as "on loan" and wait until it is returned by the borrower, or (2) to conduct a separate audit of the circulation system.

We performed an audit of the circulation system to ascertain its effectiveness in identifying items that are truly on loan. By establishing the reliability of the circulation system, we could then rely on it when either performing tests on the whole catalog or a segment of it. Sample items indicated to be "on loan" by the catalog record would be assumed to exist and not have to be recalled.

Librarians familiar with the circulation system expected the operation to be fairly accurate. Again, considering the resources available to perform the audit, the general purpose of the collection, its accessibility to the public, and the general profile of the users, the collection development officer determined that she would be comfortable with the circulation system if we could test a sample of records indicating the items were "on loan" and conclude that no more than 3 percent of the records were in error (Step 3) and with a 10 percent risk of concluding that the deviation rate was lower than it actually was (Step 4). Based on her knowledge of the collection, the librarian estimated an expected deviation rate of .5 percent. (Step 5) Again, using a lower risk would have caused the sample size to be larger or using a higher maximum deviation rate would have caused the sample size to be smaller. Had the expected deviation rate been higher, the required sample size would have been larger. Again, using a table we determined the required sample size to be 140 items. (Step 6) The sample was drawn from the circulation database of items on loan in the same manner as the book items were drawn from the catalog. (Step 7)

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Items selected that were on loan for a period of three weeks or less were "flagged" in the circulation system record. When the books were returned, the flag prompted the circulation clerk during the discharge procedure to verify the sample item. Items on loan for periods longer than three months were requested through the OLIS recall routine. On receipt, these likewise were verified. (Step 8) Of the 140 records, one was determined to be incorrect, yielding a computed upper deviation rate of 3 percent. (Step 9)

Of the 400 catalog records tested in the catalog-to-collection test, 10 book items could not be located on the shelf. The best estimate of the percentage of catalog records that indicate a book is on the shelf when it is not is 2.5 percent (10/400). Using a table to evaluate results of the audit, we may conclude with a 10 percent risk that the maximum error rate is 4 percent.

While performing the test of catalog records, we noticed that the barcode numbers on a few items in the sample list did not match the barcode numbers affixed to the books. To make using the sample size table easy and have a basis for evaluating our results, we selected at random, 10 additional book items from the catalog to replace those missing from the shelf. This enabled us to have a sample of 400 items on which we could evaluate the barcoding. Of the 400 items selected for audit, the barcoding on 9 items was inconsistent with the catalog. Using the table to evaluate results, we were able to conclude with a 10 percent risk of concluding that the occurrence rate is lower than it actually is that the maximum deviation rate was 4 percent. This finding was consistent with the rate expected by the collection development officer.

THE COLLECTION-TO-CATALOG TEST

The primary objective of the collection-to-catalog test is to determine the percentage of items on the shelf for which a corresponding catalog record does not exist or for which the catalog record is inaccurate. (Step 1) Specifically this entails examining records for a sample of the items on the shelf. Since the catalog record is the means of access to individual items in the collection, inaccuracies in the bibliographic information on the record or the total absence of any catalog record may render the item inaccessible to the user. (Step 2)

If a main entry cannot be traced from the shelf item to the corresponding catalog record, then, for audit purposes, a deviation has occurred. Similarly, if a main entry can be successfully traced back to the appropriate catalog record but the information on the record is inconsistent with that on the book item (call number, barcode number, location, etc.) an error may have occurred. For purposes of this test, an error occurred only if a catalog record could not be located, or if the call number or barcode number on the shelf item did not properly match the catalog record.

Sampling the Collection

Two basic alternatives were available for sampling the collection: sampling directly from the items on the shelf, or sampling these items indirectly through the catalog record. Since every item on the shelf must have an equal chance of being selected, sampling directly from the shelf was unattractive for the following reasons:

- No convenient means existed for applying random numbers directly to individual shelf items; and

- Size and configuration of large academic collections generally inhibit sampling methods that identify individual items by their physical location, that is, as a certain item, on a certain shelf, on a certain row, etc.

In an effort to obtain a sample that was not subject to the human limitations of auditors, we used a random number generator to identify a collection of random records from the catalog. Using the selected catalog records, we identified shelf items to include in the sample. Specifically, we defined the sample items to be the fifth item on the shelf after (or to the right of) the randomly selected book. If the book matching the randomly selected record was not on the shelf, we counted over from where it should have been. In this manner a sample was drawn from the collection which preserves the necessary randomness yet does not become merely a mirror image of the catalog sample upon which it was based.

> "We were able to conclude with a 10 percent risk that no more than 4 percent of the barcodes were incorrect in the test of the catalog-to-collection test."

The possibility that a significantly large portion of the collection could be unintentionally missing from the catalog records was dismissed on the basis of the fact that the collection is being constantly accessed through the catalog by legions of sophisticated users. In effect, the collection is being unsystematically audited by knowledgeable users expecting to find specific items in every field of the collection. Were a significant block of the collection to be unrepresented in the catalog, user complaints would readily provide notice of the problem.

Using the technique outlined above, we drew a sample of 400 items from the shelf. We found 8 items incorrectly barcoded. Using the table to evaluate results, we were able to conclude with a 10 percent risk that no more than 4 percent of the barcodes were incorrect in the test of the catalog-to-collection test. Had we found 12 items barcoded incorrectly, we would have concluded that no more than 5 percent of the barcodes were incorrect.

The shelf items were matched to a catalog record by searching for the main

entry in the catalog file. Of the 400 items, only one lacked a findable record, yielding an upper computed deviation rate of 1 percent. Ten items lacked a proper barcode match, confirming the 4 percent computed upper deviation rate found in the catalog-to-collection test.

SEGMENTING THE POPULATION

Because the state's recommendation required that the Library's physical inventory be examined, the audit test included the entire collection. However, because of the diversity of items in a large library collection, the overall findings produced may not be indicative of individual segments that make up the collection.

Large collections are often classified into distinct units serving specific purposes. The bases for such classification vary widely, and may include type of material, function, subject area, proximity to primary user group, and format of material. For example, libraries often have distinct and separate reference collections, rare book collections, microforms holdings, branch libraries, etc., each serving its own set of purposes and constituencies.

A reference collection, for instance, will not only be housed apart, but more than likely will experience a much higher level of use than a library's rare book collection. While, generally speaking, items in the rare book collection will be of greater value in terms of replacement cost, items of the reference collection will be of greater value in terms of meeting access and user demands. Similarly, the use of a reference collection is frequent and continuous, thus yielding an expectation that a greater percentage of items in this area will be discovered missing or mis-shelved. On the other hand, use in a rare book collection tends to be relatively low and controlled, giving rise to the expectation that very few if any items will be unlocatable.

Segmentation of the population for audit purposes does not necessarily have to conform to the physical arrangement of the collection. The scope of an audit can accommodate any population configuration that can be readily defined. For example, it is not uncommon for certain areas within the Library of Congress classification system to experience a much higher level of use than others. Therefore examining all items in a certain call number range may be useful regardless of material type or location. In areas of the collection in which information becomes quickly obsolete, such as scientific and technical journals, examining only those items

acquired and cataloged within recent years may be useful. Indeed, any parameter or combination of parameters may be used to define the population as long as the conditions for setting these parameters can be clearly identified in the catalog record.

These operational distinctions afford the auditor a convenient opportunity to narrow the focus of the examination and, thus, learn more about a specific segment of the library's holdings. By restricting the test procedures to managerially significant areas of the collection the auditor can make inferences about peculiarities of each specific area. Because each segment has its own level of use, value, and prescribed expectations, an audit can be tailored to take advantage of the peculiar characteristics of each segment. At the time the physical inventory was being completed, a subsidiary audit was performed on the juvenile literature collection, an identifiable segment of the Library's holdings.

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The juvenile literature collection is a heavily used entity supporting the curriculum and general readership. It contains a distinct genre of book items and is shelved as a separate unit. Unlike the remainder of the Library's collections, the juvenile literature books are cataloged according to the Dewey Decimal classification system. Because of high use demand, librarians expected the rate of missing books in this segment to be higher than that for the collection as a whole.

Since we were unsure of the rate to expect, we selected a sample of 300 titles from the juvenile literature collection, audited them, and then used the evaluation of results tables to see what conclusions we could reach. We determined that 12 items could not be located. Hence we could conclude with 10 percent risk of concluding that the occurrence rate is lower than it actually is and that the maximum percent of books missing was 6 percent. Using a different table, we could conclude with 1 percent risk that the maximum occurrence rate was 8 percent. We chose not to perform a collection-to-catalog test because the procedures for acquir-

ing and cataloging juvenile literature books are identical to those for all other books in the collection and no factors exist to suggest otherwise. In other words, we felt the larger collection-to-catalog test identified a deviation rate that was indicative of the rate that would have been found in a separate collection-to-catalog test for the juvenile literature collection.

CONCLUSION

Attribute sampling has been shown to be a useful technique for estimating the maximum portion of a population having an attribute of interest to librarians. Major advantages of the technique are that a user may examine a very small portion of the population and achieve an estimate of the population characteristic with very low risk of misstatement. Further, because tables are available for determining sample size and evaluating results, the techniques do not require complex statistics.

The auditing paradigm illustrated in this article can be applied to a broad range of collection management issues, particularly those requiring confirmation of some prescribed characteristic of the collection, the catalog, or some subset of the collection or catalog. Attribute sampling can be applied, for example, to determine the error rate in a circulation system, the accuracy of the catalog record, the prevalence of errors in the binding routine, or the occurrence of any existing condition in the collection or catalog that can be well defined. Similarly attribute sampling may be applied as an analytical tool for making cost projections for proposed projects or ongoing operations. For example, a user may wish to determine the portion of a collection that requires weeding, or the volume of holdings needing conversion from the old Dewey classification system in order to estimate the resources needed to complete the project. Because this methodology allows the user to make mathematically quantifiable inferences from an examination of a relatively small number of items, auditing with attribute sampling is both an effective and economical collection management tool.

APPENDIX

APPLYING ATTRIBUTE SAMPLING

(For a comprehensive description of the attribute sampling and tables on which the following steps are based, see Jack E. Kiger and Kenneth Wise, "Attribute Sampling: A Library Management Tool," *College & Research Libraries*, 54 (November 1993): 537-549.

1. **Determine the Objective of the Statistical Inference**. When using attribute sampling, a user determines a maximum acceptable percentage for an attribute such as the maximum percentage of catalog records for which the item is missing.

2. **Define the Population and Sampling Unit**. The sampling unit is the individual item that possesses the attribute being examined and the population is a collection of all the sampling units. A user's objective determines the population and sampling unit. To make an inference about the circulation records, the user should examine the characteristics of the catalog records. The population would be all the catalog records. If the objective were to determine whether items reflected in the catalog as on loan were on loan, the population would be all records showing items on loan.

3. **Set the Maximum Tolerable Deviation Rate**. Attribute sampling techniques enable a user to project the maximum occurrence rate of an attribute in a population such as the maximum portion of catalog records that indicate the item is on the shelf when it really is not. To determine the required sample size, a user must specify a maximum tolerable deviation rate. For example, while a librarian may prefer complete accuracy of the catalog records, given the resources available, he or she may be satisfied to conclude that no more than 5 percent of the records indicate the item is on the shelf when it is really not. The required sample size varies inversely with the tolerable deviation rate, i.e., as the tolerable deviation rate increases, the required sample size decreases. (A variation of attribute sampling known as Discovery Sampling should be used when the user expects the occurrence of deviations to be very rare.)

4. **Set the Risk of Concluding that the Deviation Rate Is Lower than It Actually Is**. When sampling, a user must accept some risk that the selected sample is not representative of the population. If the sample is not representative of the population, the estimate of the deviation rate will not be correct. A primary benefit of attribute sampling is that it enables the user to specify the risk or probability that the estimate of the deviation rate is lower than it actually is. The amount of risk

to accept is a matter of judgment. Auditors frequently use a 5 or 10 percent risk.

5. **Estimate the Deviation Rate in the Population**. A user may estimate the population deviation rate based on previous experience or a small sample of items. For example a user could select a sample of 50 catalog records and determine the deviation rate for that sample. The closer the expected population deviation rate is to the tolerable deviation rate, the larger the required sample size.

6. **Determine the Sample Size**. After estimating the deviation rate in the population, setting a risk of concluding the deviation rate is lower than it actually is, and setting the tolerable deviation rate, a table such as that shown in the referenced article can be used determine the sample size. A user specifying a tolerable deviation rate of 5 percent with an expected deviation rate of 3.5 percent and accepting a risk level of 10 percent would select a sample of 400 items.

7. **Select the Sample**. Each item should have an equal chance of being selected.

8. **Examine the Items in the Sample**. Each record selected should be tested to determine if it is represented by an item on the shelf. Of the 400 item sample, 10 items (2.5 percent) could not be located on the shelf.

9. **Evaluate the Sample Results.** An evaluation of results table may be used to estimate the maximum deviation rate. By locating the actual sample size on the left of the table and looking across the row to the column indicating the number of deviations found in the sample, a user may find the computed upper deviation rate (4 percent) at the top of the column. The user may conclude with 10 percent risk that the maximum percent of incorrect records is 4 percent.

NOTES AND REFERERENCES

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