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Symposium on Remote Sensing for Vegetation Damage Assessment*

Resolutions submitted during the Symposium, and the disposition of those resolutions, are presented. A list of all invited and presented papers is appended.

Introduction

The "symposium on Remote Sensing for Vegetation Damage Assessment" was held on February 14, 15, and 16, 1978, to assess the "state-of-the-art" in theory, technology, case studies, and practical application. Four invited papers, one for each theme area, and 27 presented papers were delivered. At the commencement of the program, resolutions concerning any area of

Abstract: *A Symposium on Remote Sensing for Vegetation Damage Assessment was held in Seattle, Washington, U.S.A., on February 14, 15, and 16, 1978. Four invited and 27 presented papers were delivered during the Symposium. The papers dealt with (i) the theory of vegetation damage detection and assessment, (ii) the technologies involved, (iii) case studies, and (iv) economics and current applications. Resolutions were called for and submitted during the Symposium, and were presented, discussed, voted upon, and their disposition decided at the end of the Symposium. The resolutions reflected the moods, present needs, and future concerns of the scientist and managers at the meeting. The resolutions asked for*

(i) ASP and ISP-Comm. VII support and encouragement of research into vegetative dysfunction relative to remote sensing;

(ii) an international study on "prvisual" or extravisual damage detection;

(iii) more precise definition of "damage" and damage classes;

(iv) coding of forest damage types in chronic vegetation damage situations;

(v) quality control through use of defined confidence levels and statements of errors of estimates; and

(vi) more effective technology information transfer at symposia, and at government or institutionally sponsored local area workshops.

One resolution was tabled, and the disposition of the approved resolutions is discussed. The publication of the resolutions is intended as notice of press in order that the appropriate parties may take effective action.

*This paper, and three of the invited papers from the Symposium on Remote Sensing for Vegetation Damage Assessment, are included in this volume of the Journal. The complete Proceedings of the Symposium, at a cost of $12.00 for members and $18.00 for non-members, may be obtained from the American Society of Photogrammetry, 105 N. Virginia Ave., Falls Church, VA 22046.

ZUSAMMENFASSUNG: *Am 14, 15, 16. Februar 1978 fand ein Symposium über die Feststellung der Vegetationsschäden durch Methoden der Fernerkundung in Seattle, Washington, U.S.A. statt. Während dieses Symposiums wurden insgesammt 31 Vorträge gehalten, davon waren vier spezielle für dieses Symposium vorbereitet. Diese Vorträge behandelten folgende Themen: (i) Theorien der Feststellung und Beurteilung von Vegetationsschäden, (ii) Fallstudien, (iii) die enhalten Gewerbekunden, und (iv) Wirtschaftlichkeit und gegewärtige Anwendungsgebiete. Es wurden während dieses Symposiums Entschlüsse gefordert, daraufhin welche vorgelegt und vorgetragen, diskurtiert und darüber abgestimmt. Am Ende des Symposiums wurden Beschlusse hinsichtlich ihre Abwicklung gefasst. Diese Entschlüsse repräsentieren die Stimmung, die gegenwärtigen Bedürfnisse und die künftigen Interessen der Wissenschaftler und der Manager, welche an dem Symposium teilnahmen. Diese Entschlüsse verlangten die Durchführung folgender Massnahmen:*

(i) A.S.P. und ISP-Comm. VII Unterstützung und Förderung der Forschung dezüglich der Fernerkundung von vegetativ bedingten anormalen Funktionen;

(ii) eine internationale Studie über die "previsual" oder "extra-visual" Schadensfeststellung;

(iii) genauere Definition von "Schaden" und klassifizierung der Schäden;

(iv) Einführung eines Verschlüsselungssystems für die verschiedenen Arten von Waldschäden in Fällen von chronischen Vegetationsschaden;

(v) Qualitätskontrolle durch statistische Mehtoden unter Angabe der Fehlertoleranz und

(vi) wirkungsvolleren Informationsaustausch über Technologien bei Symposien und regionale Arbeitsgruppen, welche von der Regierung oder von Institionen gefördert werden.

Ein Entschluss wurde für eine unbestimmte Zeit zurückgelegt und die Abwicklung der angenommenen Entschlüsse wird diskurtiert. Die Veröffentlichung der Entschlüsse soll in Form einer Pressenotiz erfolgen, sodass die zuständigen Parteinen wirkungsvoll Tätig werden können.

RÉSUMÉ: *Un Symposium sur la télédétection pour évaluer les dommages causés à la végétation a eu lieu à Seattle, Washington, U.S.A., le 14, le 15, et le 16 février 1978. A ce symposium ont contribué orateurs invités at 27 présentés. Leurs exposés traitient de (i) la théorie pour l'évaluation et la détection des dommages causés à la végétation (ii) les technologies impliquées (iii) des études de cas particuliers et (iv) des considérations économiques et des applications courantes. Dés resolutions se sont révélées nécessaires et ont été proposées pendant le symposium. Elles ont été présentées, discutées et votées, et il a été décidé de les mettre en oeuvre à la fin due symposium. Les résolutions refléctaient l'état d'espirit, les besoins actuels et les préoccupations pour l'avenir des hommes de science et des directeurs qui ont assisté à la réunion. Les résolutions demandaient:*

(i) Le soutien A.S.P. et ISP-Comm. VII et l'encouragement de la recherche en ce qui concerne la dysfonction de la végétation relative à la télédétection;

(ii) une étude internationale de la détection des dommages "previsuelle" et extra-visuelle;

(iii) une definition plus precise de la notion de "dommage" et du classement des dommages;

(iv) la codification des types de dommages causés à la forêt dans des situations de dommages chroniques de la végétation;

(v) le contrôle de la qualité grâce à l'utilisation de niveaux de certitude définis et de marges d'erreur dans les estimations et

(vi) un échange de renseignements technologiques plus efficace par des symposiums ou des ateliers locaux financés et encouragés par le gouvernement ou par des institutions.

Une résolution a été ajournée et la mise en eruvre de celles qui ont été approuvees est maintenant discutée. La publication des résolutions servira d'avis de presse afin que les parties concernées puissent prendre les dispositions nécessaires.

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remote sensing for vegetation damage assessment were called for, and these were to be submitted during the Symposium. At the end of the meeting, the resolutions were presented to the participants. They were discussed, voted upon, and the disposition of each was decided. Nine resolutions subsequently were subdivided into five groups:

(a) 1, 2: Investigations and research
(b) 3: Monitoring
(c) 4, 5, 6: Definition and coding
(d) 7: Quality control
(e) 8, 9: Information exchange

The resolutions as they were presented, voted upon, and disposed of are—

INVESTIGATIONS AND RESEARCH

Resolution No. 1. Presented by Paul M. Seevers and John F. Wear.

Whereas vegetation damage is an anatomical expression of physiological dysfunctions caused by any number of agents affecting the vegetation; and

whereas it would seem that an understanding of the relationship of physiological dysfunctions to their appearance on remote sensing data would be of significant value in the interpretation of vegetation damage;

be it resolved that the ASP and Comm. VII, ISP support and encourage further investigations of the relationship of physiological vegetative function to remote sensing data.

Voting: Yes — Unanimous
No — 0

Disposition: Suggested that the Remote Sensing and Interpretation Division (RS&I) of ASP, and Comm. VII ISP be made aware of the passed resolution, and that the subject be listed as an agenda item at future meetings.

Resolution 2. Presented by L. Fox and P. Murtha

Whereas members of the remote sensing community with an interest in "previsual" detection of vegetation damage of "stress" should meet;

whereas such a group should include those who have experienced success and/or failure in "previsual" detection;

whereas "previsual" detection has been oversold (erroneously or otherwise) in the past and the credibility of the interpreter is suspect; and

whereas our credibility must be established now;

be it resolved that a proposal for a cooperative research project to investigate the previsual or "extravisual" status of vegetation damage detection should be prepared and submitted to a major funding organization, that such a research project should be replicated across North America, and that it should be subject to rigorous statistical analysis.

Voting: Yes — Unanimous
No — 0

Disposition: It was suggested that a Workshop be called at the 1979 ASP annual meeting to discuss drafting of the project.

MONITORING

Resolution 3. Presented by Pat O'Neil.

Whereas remote sensing for vegetation damage assessment is dependent on

(a) the nature of the problem, e.g., biotic or abiotic causes,
(b) the manifestation of the problem,
(c) the skill of the interpreter,
(d) camera, film, focal length, and processing,
(e) formal selection, e.g., transparency vs. paper print, and
(f) generation;

be it resolved that monitoring agencies concentrate on

(a) the insect: disease complex, or
(b) specific causes.

It was recognized during the discussion that either the complex or the specific cause could be the target during remote sensing surveys, and that each had its own priority. It was also recognized that the variabilities and uncertainties as indicated above would continue to be problems.

Disposition: The resolution was tabled.

DEFINITION AND CODING

Presented by B. Myers, P. Murtha, and C. D. Sapp.

After preliminary discussion, resolutions 4, 5, and 6 were re-worded and condensed into two resolutions numbered 4 and 5 and were presented for voting:

Resolution 4. Reworded by C. D. Sapp and P. Murtha.

Whereas there are wide discrepancies in the use of the words "damage" and "injury;" and whereas there are wide variations in the literature;

be it resolved that authors take greater care in use of the words, and carefully define "injury," "damage," and damage class descriptions (i.e., light, medium, heavy).

Voting: Yes — Unanimous
No — 0

Resolution 5. Reworded by B. Myers.

Whereas there are wide descriptions in the manifestation of damage,

be it resolved that authors classify damage types according to previously defined keys or coded classifications (e.g., Murtha, 1972, 1976).

Voting: Yes — 12
No — 1
Abstentions — 17

(The agriculturalists felt that the code for forest damage types did not apply to agricultural crops and therefore they abstained. Others felt that in some cases there was no need, and yet others who had dealt with chronic damage, and varieties of manifestations, found it an excellent means to communicate both to other scientists and in interpreter-training.

Disposition: It was agreed that the journal editors should be notified of the result of the reworded resolutions 4 and 5 and that, where possible and if necessary, coding for forest damage be used during remote sensing for vegetation damage assessment of chronic damage symposiums.

QUALITY CONTROL

Resolution 7. Quantification of Remote Sensing Data. Presented by R. C. Heller.

Be it resolved that vegetation damage scientists report their findings from studies and surveys with quantitative statements which describe the amount of damage (trees, hectares, etc.) with an error estimate with defined confidence limits, whenever possible.

Voting: Yes — Unanimous
No — 0

Disposition: The decision will be made known to the Remote Sensing Working Groups in the Society of American Foresters, Canadian Institute of Forestry, and the RS&I Division of ASP, and in addition the respective editors are to be notified.

INFORMATION EXCHANGE

Resolution 8. International Speakers. Presented by Bill Clerke.

Be it resolved that an effort be made to increase the international exchange of information on remote sensing research and applications for vegetation damage assessment. It is suggested that this objective may be accomplished in part by encouraging the submission of papers to remote sensing symposia from outside the host country and by permitting the authors to send slides and a cassette tape as a substitute for oral presentation.

Voting: Yes — Unanimous
No — 0

Disposition: ASP organizing committees to be notified.

Resolution 9. Technology Transfer. Presented by J. Caylor.

Whereas technology transfer and training are critical issues in resource evaluation by means of remote sensing techniques;

whereas university, extension, or college level courses are available but inaccessible because of employment constraints; and

whereas individuals can schedule one to one-and-a-half days to discuss remote sensing problems in a workshop atmosphere provided they are located within a budget and a realistic travel time constraint;

be it resolved that University Extension facilities and government agencies provide more local workshops and short courses in order for managers and users to become aware of basic photo interpretation and up-to-date remote sensing techniques.

Voting: Yes — Unanimous
No — 0

Disposition: Remote sensing working groups should be advised, and should attempt to prepare lists of short courses for advertisement at least one year in advance. The year's notice was thought necessary because of agency budgeting. It was suggested that the Education Committee of ASP could make remote sensing short courses more noticeable by placing ads in resource journals.

DISCUSSION OF RESOLUTIONS*

The resolutions, their disposition, and

*Unless otherwise indicated by a date, papers mentioned in this discussion were presented during the Symposium, and these papers may be found listed in Appendix I.

related discussion reflected the mood of the symposium, and as such indicated the present needs and future concerns of scientists and resource managers responsible for remote sensing for vegetation damage assessment.

Perhaps the greatest need and concern was stated in Resolutions 1 and 2, which were concerned with research into vegetation dysfunctions and previsual or extravisual detection of vegetation damage. The consensus was that "previsual" or extravisual detection of vegetation damage as indicated by remote sensing data needs to be thoroughly tested with replicated experiments across the continent. Equipment, techniques, and procedures for the experiment need to be standardized. Results should be comparable, repeatable, and stand the test of rigorous statistical analysis. Consideration will have to be given to a careful definition of the meaning of "previsual damage detection," and should answer the questions

(i) "Does previsual detection of damage occur, and if so, when does it occur?";
(ii) "What are the conditions for detection and their limitations?", and
(iii) "Do the limitations prevent application?."

Consideration also should be given to the relativity of the answers. For example, is previsual detection relative to

(a) subsequent human description on the ground;
(b) aerial photographic detection at specified scales;
(c) a given or specific type of remote sensor;
(d) physiological properties and/or dysfunctions of the plant;
(e) a given species or all species of plants;
(f) spectral reflectance curves as determined *in situ,* in the laboratory, or a general sample of curves;
(g) the interpretation techniques or equipment; or
(i) all, none, one, or some of the above.

Murtha, in his lead-off paper at the Symposium, asked how one "ground-truths" a pre-visual or "extravisual" damage symptom. It was suggested that there were possibilities that in some instances the damage may never become visual. A plant could, hypothetically, display "damage" or "injury" in an extravisual region of the spectrum, and then recover. If damage is taken as a "change" in the near-infrared reflectance, regardless of whether it increases or decreases, how much damage is necessary before it can be called damage? Murtha (1972) defined it as a "deviation from the normal functioning of the plant, and related it to normal or expected spectral reflectance patterns." A detrimental change in form was also defined as damage, but since a form change can be seen, there is little need to be concerned here with defoliation, stem breakage, etc.

The accepted definition of damage will be the key to the answer. Fox, in his paper "The Elusive Dream," reviewed several papers on the previsual detection of damage, and gave special attention to canopy density. A ground-based thermal-scanning system was used by Heikkenen to record "previsual detection" of stressed pine, who suggested that the best wavelengths were in the thermal region rather than the photographic region. Gausman *et al.* reported on the use of certain photographic films with certain filters, and suggested that anything seen on photos and not seen on the ground was previsual detection. It seems that the Resolutions 1 and 2 were designed to come to grips with the question.

Unfortunately, Resolution 3 was tabled because it pinpointed many problems facing the managers who want to make more use of remote sensing data. A feeling of frustration is caused by the tremendous technological advances of research in vegetation damage interpretation and the utter lack of adequate application at a more sophisticated level by the resource managers themselves. Could it be that it is time that higher management levels recognize that in each resource analysis team a remote sensing specialist is now needed along with the forester, hydrologist, wildlife specialist, biometrician, etc.? The days are long gone when any resource specialist could look through a stereoscope and become the instant remote sensing expert. The research papers have indicated the advanced knowledge in remote sensing techniques for vegetation damage detection and assessment. Resolutions 8 and 9, although very valid, could be only short-term solutions to the real problem poinpointed by Resolution 3.

Resolution 3 also pinpointed an open management and philosophic debate between two schools of thought. Remote sensing only for specific damages follows the traditional approach. The underlying belief seems to indicate that in one forest area only one agent will be responsible for damages. The opposite belief indicates that an "insect-disease" complex operates in any forest situation. Given remote sensor data, and the difficulty in designating the cause of

damage to vegetation, together with ease in manifestation description, it would seem that the most logical approach would be to monitor the forest "disease-insect" complex and inventory damages from specified causes.

Resolutions 4 and 5 were somewhat related to the first two resolutions. In order to adequately study remote sensing for vegetation damage assessment, terms have to be defined. Generally, "injury" or "damage" and, most frequently, the word "damage", have to be used relative to remote sensing. The major problem even in evidence in the presented papers is that damage can mean anything from a defoliated, dead tree to a slight change in foliage color. The associated problems are caused by different evaluations of light, medium, and heavy damage. Frequently, the evaluations are subjective and expressed only in general terms. In any application, the terms have to be *precisely* defined, and, it is hoped, some standardized terms or statements may at some time be provided. But until that time, authors were encouraged to be very precise in their definitions.

Because of very strong probabilities of major commission or omission errors in complex situations in which there is a wide variety of damage manifestations, there is a strong need to code the damage manifestations into categories. Resolution 5, reworded by B. Myers, recommended that authors classify damage types according to the key by Murtha (1972, 1976), or such other key as may be available. Authors were encouraged to cite publications. Perhaps the most pressing need for coding of forest damage types is in the complex chronic damage situations. Coding into damage types facilitates communication from one interpreter to another, monitoring over a period of years, and counting of damaged tree numbers. In essence, coding becomes essential in order to implement the quality control aspect, as demonstrated by Resolution 7.

It goes virtually without saying that, in order for the credibility of remote sensing data interpretation to be increased, a quality control aspect is needed. Resolution 7 asked for quantitative statements with defined confidence limits and error estimates given. In order to achieve these estimates, certain numbers of photo plots will have to be field checked.

The final two Resolutions, 8 and 9, dealt with technology information transfer, and are not only relative to remote sensing for vegetation damage assessment, but also to all fields of interest in remote sensing.

Summary

Remote sensing for vegetation damage assessment has been the subject of considerable research into theories and technologies. The resolutions as they were presented and voted upon expressed present needs and future concerns of scientists and resource managers relative to remote sensing and vegetation damage detection and assess-ment. There is keen interest in the investigation of vegetative dysfunctions relative to remote sensing. An international study in previsual, or extravisual, damage detection was called for. Some scientists, working with chronic forest vegetation damage situations, called for coding of forest damage types in order to facilitate communication among interpreters, in reports, assessing or quantifying damage, and to provide a means to monitor damage. There were many expressions of the need to precisely define terms such as damage, and light, medium, and heavy damage. Quality control with expressions of confidence levels and errors of estimates were unanimously asked for. Indications were given that governmental organizations and university extension services should provide more local training sessions for those involved in current practical applications.

In conclusion, it is felt that the art and science of remote sensing for vegetation damage assessment has advanced considerably in research and understanding in the basic theories and technologies involved, that numerous case applications have demonstrated the many potentials, but that limitations lie in the lack of adequate technology information transfer at the grassroots, working management level.

The publication of these Resolutions in the Preceeding is intended to call attention to the approved resolution, in order that the appropriate parties may take effective action.

References

Murtha, P. A. 1972. *A guide to air photo interpretation of forest damage in Canada.* Can. For. Serv. Public. 1291. 63 pp.

———. 1976. Vegetation damage and remote sensing: principal problems and some recommendations. *Photogrammetria.* 32(1976): 147-156.

Appendix 1

Invited and presented papers, Symposium on Remote Sensing for Vegetation Damage Assessment.

Murtha, P. A. Remote Sensing and Vegetation Damage: A Theory for Detection and Assessment. (*Invited Paper*). Fac. Forestry, U.B.C., Vancouver, B.C.

Heikkenen, H. J. Previsual Detection of Stressed Lobolly Pine (*Pinus Taeda*) V.P.I. Blacksburg VA.

Gausman, H., *et al.* Using Reflectance and Photography to Detect Ozone Damage to Cantaloupe Plants. U.S.D.A., A.R.S., Weslaco, Texas.

Fox, L. Previsual Detection: The Elusive Dream. Humboldt State Univ., Arcata, Calif.

Fox, L. The Effect of Canopy Structure on the Measured and Calculated Reflectance of Conifer Forests in Michigan, Humboldt State Univ., Arcata, Calif.

Tonelli, A. M. The Use of Vegetation as a Transducer for Environmental Pollution. Aerospace Remote Sensing Consul. Milan, Italy.

Weber, F. P., and Irv Duggan. (*Invited Paper*). The Technology of Remote Sensing for Vegetation Damage Assessment. U.S.D.A. - F.S., NASA - JSC, NFAP. Houston, Texas.

Williams, P. G. A Wing-tip Camera System for Large-Scale Photography I.R.P. Vancouver, B.C.

Gaucher, D. W., *J. E. Walker,* and J. R. Scholt. Applications of the Photometric Process in Monitoring Vegetation Damage Due to External Stresses. Calspan Corp., Buffalo, N.Y.

Clerke, W. H., and R. O. Mahan. The Application of Digital Terrain Models and Space Resection Techniques to Digitization of Southern Pine Beetle Infestations: Delineated on Large-Scale Photographs. U.S.D.A. - F.S., S & PF, Atlanta, Ga.

Lee, Y. J., and J. F. Wear. Microdensity to identify Douglas-fir Tussock Defoliation on Color-Infrared Aerial Photos. CFS, Victoria, B.C. and U.S.D.A. - USFS, Portland, Ore.

Hogan, H. E., and R. P. Madding. Detection and Mapping of Spruce Budwork Infestations. Inst. for Env. Studies, Univ. of Wis., Madison, Wis.

Williams, D. L., and M. L. Stauffer. Monitoring Gypsy Moth Defoliation by Applying Change Detection Techniques to LANDSAT Imagery. Earth Res. Branch, NASA Goddard S.F.C., Greenbelt, Ma.

Heller, R. C. Case Applications of Remote Sensing Vegetation Damage Assessment (*Invited Paper*). College of Forestry, Univ. of Idaho. Moscow, Idaho.

Bird, T., B. J. Myers, and D. A. Ratkowsky. Recognition of Patterns of Damage in Tall Forests in Australia. CSIRO. Hobart, Tasmania and Canberra, Australia.

Bradshaw, J., and R. Chandler. Full Coverage at Large Scale. Forests Dept., Western Australia.

Myers, B. J., and T. Bird. Detection of Crown Diebacks in Australian Eucalypt Forests on Large-Scale Aerial Photographs. CSIRO, Canberra, Australia.

Fairweather, S. E., M. P. Meyer, and D. W. French. The Use of CIR Aerial Photography for Dutch Elm Disease Detection. Univ. of Minn., St. Paul, Minn.

Miller, W. A., and R. C. Heller. Remote Sensing Approach to Identifying Preferred Douglasfir Tussock Moth (*Orygia pseudotsugato* McD.) Sites. EROS Data Centre, Sioux Falls, S.D.

Schultz, M. E. Remote Analysis of Forest Tree Mortality in Calif. Univ. of California, Berkeley, Calif.

Klein, W. H., *et al.* Multiphase Airphoto Assessment for Annual Losses Caused by the Mountain Pine Beetle in Lodgepole Pine. U.S.F.S. Davis, Calif.

Leupold, R. C., J. B. Mathies, and R. J. Kohut. Use of Color Infrared Aerial Photography for Documenting Baseline Vegetation Stress in Environmental Impact Assessment. Environ. Research & Tech., Inc. Concord, Mass.

Sapp, C. D. Detecting the Effects of SO_2 Emissions on Vegetation by Remote Sensing. T.V.A., Muscle Shoals, Alabama.

Watkins, T. A Survey of Two Conferences on the Economics of Remote Sensing: With Special Emphasis on Remote Sensing of Vegetation Damage Assessment. *Invited Paper.* Dept. Econ., San Jose Univ., San Jose, Calif.

Murtha, P. A., and J. W. E. Harris. LANDSAT Evaluation of Tussock Moth Defoliation. Fac. For., U.B.C., Vancouver; C.F.S., Victoria, B.C.

Gregg, T., K. Russell, and E. Knudtson. Detection of Armillaria Root Rot Damage with Color Infrared Photography. Washington State Dept. of Nat. Res., Olympia, Wash.

Chatuvedi, A. C. Vegetation Damage Surveying in India. Irrigation Comm. U.P., Canal Colony, Lucknow, India.

Backman, R., R. Johnsy, and *T. Gregg.* Washington State Forest Insect Survey—Combining Aerial Sketch Map and Remote Sensing Techniques. Washington State Dept. of Nat. Resources, Olympia. Wash.

Schaefer, E. L. Remote Sensing for Determination of Seedling Survival. Schaefer Assocs., Newport Beach, Calif.

Myers, B. J. Remote Sensing of Vegetation Damage to Assess the Effectiveness of Prescribed Burning in Australia. CSIRO, Canberra, Australia.

McKim *et al.* Inundation Damage to Vegetation at Selected New England Flood Control Reservoirs. U.S. Army Cold Regions Res. & Eng. Lab. Hanover, New Hampshire.

William, D., and J. Shines. Operational Remote Sensing for SO_2 Vegetation Damage. Environ. Protection Agency, Lockheed Electronics, Las Vegas, Nev.

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