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The Moquah Barrens Research Natural Area: Loss of a Pine Barrens Ecosystem



Forest Service
Northern Research Station
General Technical Report NRS-161
April 2016

Abstract

The Moquah Barrens Research Natural Area (RNA) was established by the Chequamegon National Forest and the Lakes States Forest Experiment Station in 1935 with a research objective well-suited to the needs of the Forest Service and the scientific understanding of ecosystem function prevalent at the time of establishment. The original research plan was never implemented, which led to a joint Forest-Station decision in 1956 to disestablish the RNA. However, that decision was never implemented. A series of management decisions made after 1956 led to the loss of the pine barrens ecosystem originally encompassed by the RNA.

This loss is not irretrievable and the work necessary to recover the original ecosystem is possible under existing RNA management guidelines. The experience of the Moquah Barrens RNA can be used by the Forest Service to improve overall management of the entire system of research natural areas. Two main areas of opportunity are identified: 1) implement an improved approach to managing official records associated with RNAs; and 2) adopt a management framework suitable for long-term ecological projects.

Cover photos, clockwise from upper left:

Plaque mounted on boulder commemorating the 1980 designation of Moquah Barrens Research Natural Area as a national natural landmark by the National Park Service. Photo by Matthew Bushman, U.S. Forest Service.

Aerial photo of Moquah Barrens Research Natural Area (area with dense tree canopy) embedded in the sparsely treed wildlife management area. Photo by Matthew Bushman, U.S. Forest Service.

Marker stake and surrounding vegetation, 2015. The stake marks one of seven permanent photographic points established by the Wisconsin Department of Natural Resources in 1973. Photo by Albert Beck, University of Wisconsin-Madison, used with permission.

Dense interior vegetation cover (2015) in Moquah Barrens Research Natural Area that resulted after 80 years of fire suppression in a fire-dependent community. Photo by Albert Beck, University of Wisconsin-Madison, used with permission.

Quality Assurance

This publication conforms to the Northern Research Station's Quality Assurance Implementation Plan which requires technical and policy review for all scientific publications produced or funded by the Station. The process included a blind technical review by at least two reviewers, who were selected by the Assistant Director for Research and unknown to the author. This review policy promotes the Forest Service guiding principles of using the best scientific knowledge, striving for quality and excellence, maintaining high ethical and professional standards, and being responsible and accountable for what we do.

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INTRODUCTION

The U.S. Forest Service maintains a subset of National Forest lands in a special management category called research natural areas (RNAs). The mission statement from the National Research Natural Area Strategy summarizes the general purpose of RNAs: "The RNAs help ensure that we maintain representation of diverse natural ecosystems for future generations. The RNA Program finds, establishes, and maintains a network of sites that provides ecological reference areas of critical importance for research, monitoring, and education" (U.S. Forest Service 1993). Only nonmanipulative research, monitoring, and educational activities are allowed on RNAs; further background information is provided by U.S. Forest Service (n.d. c). One special feature of RNAs is that data collected on these lands are to be preserved by the Forest Service for later use (U.S. Forest Service 2005).

One of the first RNAs to be established was the Moquah Barrens RNA (originally called the Moquah Natural Area). Located on the Washburn District of the Chequamegon-Nicolet National Forest[1] (CNNF), in Bayfield County, Wisconsin, the RNA contains elements of the globally rare pine barrens community, part of the Northwest Sands Ecological Landscape (Wisconsin Department of Natural Resources [WDNR] 2015a), which runs southwest to northeast across northwestern Wisconsin (Fig. 1). Moquah Barrens RNA encompasses an entire surveyed section (640 acres; T48N-R7W, Section 23).

[1] The Chequamegon and Nicolet national forests have been administered as a single unit, the Chequamegon-Nicolet National Forest, since 1993.

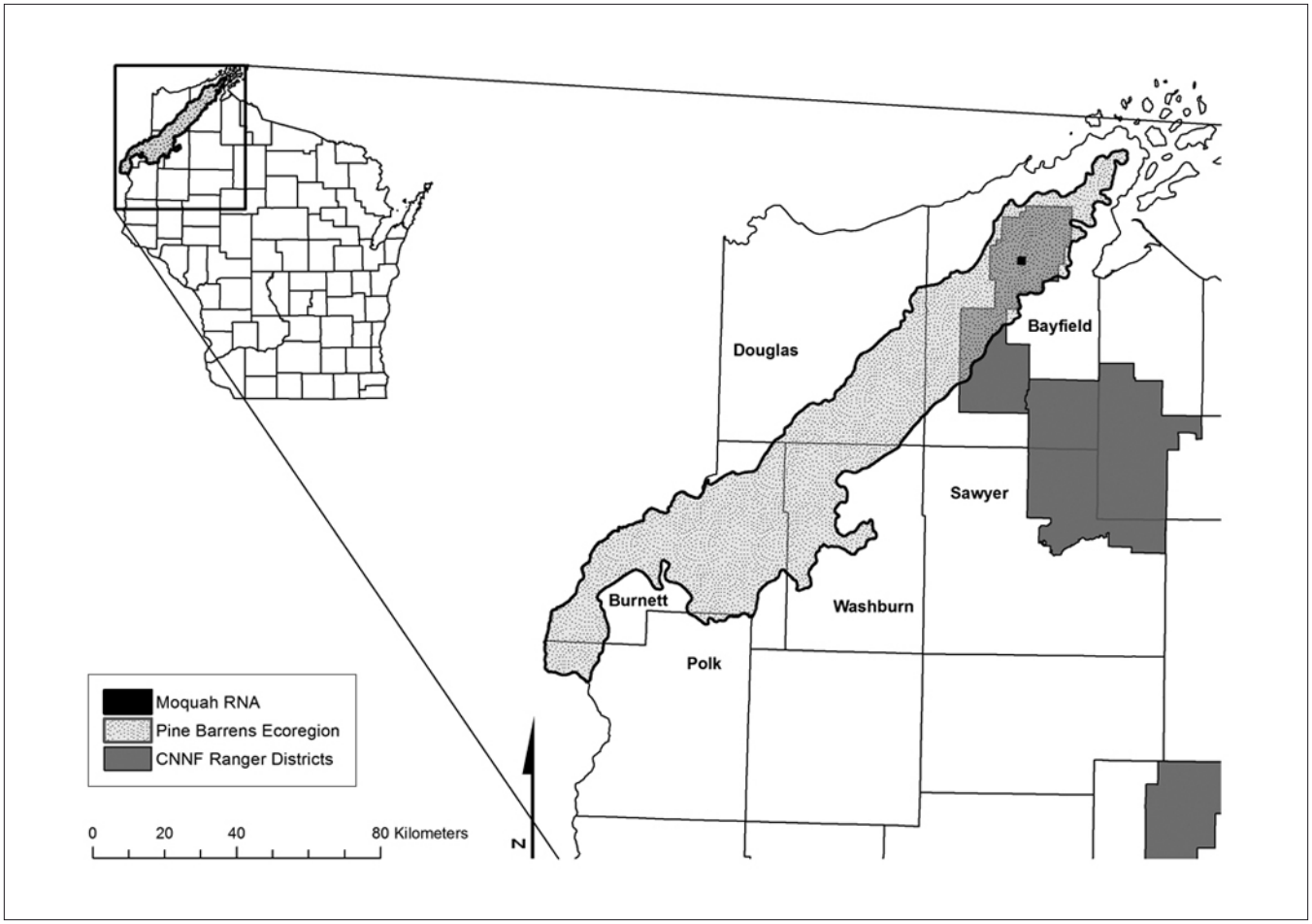


Figure 1.—The pine barrens ecoregion in northwest Wisconsin. Ecoregion shapefiles are available at http://www.epa.gov/wed/pages/ecoregions/wi_eco.htm.

This review of the Moquah Barrens RNA's development serves as companion material for a RNA research data publishing project executed in cooperation with CNNF staff. We have four objectives. Our first objective is to set the site's pre-establishment context (readers interested in the general historical context may consult a history of the Forest Service [e.g., Bergoffen 1976, Williams 2000]). Our second objective is to use the administrative record to describe the RNA's history. Under this objective, we document: (a) the establishment of the Moquah Barrens RNA including its original purpose; (b) subsequent events and activities that changed the purpose of the RNA; and (c) management and recreation activities on the site. Our third objective is to document the scientific studies conducted on the site. This objective includes descriptions of three data sets published as part of our project. Our fourth objective is to synthesize what we learned from the project to inform future land management of this RNA and administrative management of RNAs generally.

MATERIALS

The primary Forest Service records used for this report are the Moquah Barrens RNA documents maintained by the CNNF Research Natural Areas coordinator and the Northern Research Station. Documents were received from the CNNF district offices in Park Falls and Washburn, WI, and the Northern Research Station records manager in Newtown Square, PA. We also received documents from the Wisconsin State Natural Areas Program. We found additional Federal documents referenced in the primary sources as needed.

PRE-ESTABLISHMENT CONTEXT

Prior to European settlement, the Northwest Wisconsin pine barrens covered nearly 2.3 million acres and were historically maintained by fire (Radeloff et al. 1999). Fires were common in northern Wisconsin during the logging years (1850-1920) (U.S. Forest Service n.d. b). These persistent fires retained open barrens habitat by preventing reseeding of jack pine (*Pinus banksiana*) (Posner and Hildebrant 2006). The Moquah Barrens RNA is located in the northern part of the pine barrens, which was dominated by red pine (*Pinus resinosa*) (Radeloff et al. 1999). Specifically for Section 23, where the Moquah Barrens RNA was established, the original General Land Office (GLO) plats show that the vegetation was mainly red pine, jack pine, and aspen (*Populus tremuloides*).[2]

ADMINISTRATIVE HISTORY

Establishment and Setting of Purpose

The Moquah purchase unit, along with other land purchases, was acquired in 1928 by the Forest Service (U.S. Forest Service n.d. b). In 1930, the Forest Service decided to set aside some of the land as a natural area; in 1932, the specific parcel was chosen because it contained "most of the different vegetation types common on the Moquah Forest" (Shirley 1934). The Moquah Barrens RNA was created under Forest Service Regulation L-20 (later became Regulation U-4) (Paddock 1961). The L-20 regulation was published in the August 15, 1936 volume of the Federal Register. It states that "the Chief of the Forest Service shall determine, define, and permanently record a series of areas of national forest land … to be known as natural areas sufficient in number and extent adequately to illustrate or typify virgin conditions of forest or range growth … to be retained in a virgin or unmodified condition for the purposes of science, research, and education" (Experimental Forests and Ranges 1936).

The RNA's establishment report (Ball 1934) received final approval on July 23, 1935, and stated the reasons for creating the natural area:

- "The object in setting aside such an area is to determine what will naturally take place on this area if it is afforded fire protection only. No cultural treatment, release cutting or any other treatment which would interfere with this natural course of events will be given."

[2] Personal communication from David Mladenoff, Professor of Conservation, University of Wisconsin, Madison, WI.

- "It is expected that the data secured from the study of this natural area over a period of years will aid in the determination of the rate at which a denuded area will reseed itself naturally to commercial species if afforded protection from fire."
- "The area will also serve as a check and comparison with adjoining and recently established plantations."

The "commercial species" referred to included Norway pine (i.e., red pine), which was the primary species that had been logged from the site in the 1880s, eastern white pine (*Pinus strobus*), and jack pine.

Of note is the statement at the end of the report: "It is believed that the establishment of this natural area is highly desirable from an experimental standpoint." Recalling that only nonmanipulative experiments were allowed on RNAs, it might appear to the modern observer that the planned exclusion of fire from a fire-dependent ecosystem constituted a manipulative experiment. However, the reigning scientific paradigm of the period for understanding vegetative ecosystems was succession—an orderly process where there is "complete and continuous or repeated invasion, in consequence of which formations succeed each other" (Clements 1905). This view of community structure held that systems moved in natural progression to a climax community controlled by relatively constant abiotic (e.g., temperature, precipitation) and biotic (e.g., soil properties) factors (Ricklefs 1973). Episodic fire was seen as an intrusive force and not a natural part of the ecosystem (Clements 1905). Therefore, its exclusion would allow the system's natural processes to proceed unhindered.

The 1934 working plan (Shirley 1934) described two baseline studies designed to provide a reference against which to measure the site's natural development. The first planned study involved creating "an accurate topographical map." The second planned study involved creating "a detailed vegetation map." This map was expected to delineate standard timber types, shrubs, and herbaceous vegetation. In particular, the map would show the locations of all Norway and jack pine seed trees. The working plan also described two longer term studies. The first of these was to be a study of natural reproduction of the "valuable tree species, such as Norway [i.e., red] or jack pine", and the second was to be a detailed floristic study. The longer term studies were proposed to be done on two permanent transects that would cross the entire section in a north to south direction. The map appended to the working plan was a general map of the extant vegetation, not the desired detailed map.

While the working plan detailed the responsibilities of the CNNF and the Lake States Forest Experiment Station[3] for carrying out the experiments and maintaining permanent records, the working plan was never implemented (Dickerman 1952, Pommerening 1948, Trochlil 1968a), and some of the original documents (e.g., original 1934 working plan map) have been lost. The likely cause for the lack of implementation was budget cuts implemented due to the Great Depression (Cowlin 1988).

Events in the Area Around Moquah Barrens RNA

Records of fires in or near the Moquah Barrens RNA during the early 1900s are scarce. The legacy of fires caused by human logging activity was one of fire suppression (Murphy 1931). However, on October 16, 1936, there was a large fire in northwestern Wisconsin near Iron River, southwest of the CNNF. Based on a retired employee's recollection, the CNNF thought the fire might have burned the Moquah Barrens RNA and resulted in salvage logging (Byers 1971, St. Onge 1994). However, while the fire appeared to reach sections to the south and west of the Moquah Barrens RNA, the fire did not appear to have reached the RNA itself (see appendix 1 for details, including a map of the affected area).

[3] The Lake States Forest Experiment Station merged with the Central States Forest Experiment Station in 1966, becoming the North Central Forest Experiment Station (later renamed the North Central Research Station [NCRS]). In 2006, NCRS and the Northeastern Research Station merged to form the Northern Research Station.

The landscape around Moquah Barrens RNA was actively managed starting in the late 1940s. In 1948, a memorandum of understanding was established between the CNNF and the Wisconsin Conservation Department (i.e., Wisconsin Department of Natural Resources, [WDNR]) to cooperate on the enforcement of State fishery and wildlife regulations (U.S. Forest Service 1948). In 1950, the CNNF and the WDNR agreed to cooperate on land management specifically for sharp-tailed grouse (*Tympanuchus phasianellus*) because "in recent years, farm abandonment, fire protection, reforestation, and natural tree growth have materially reduced the large brushy areas and openings which characterize good sharptailed and pinnated grouse [i.e., greater prairie chicken *Tympanuchus cupido*] habitat" (U.S. Forest Service 1950). Parts of T48N-R7W Sections 22, 24-37, which surround the Moquah Barrens RNA to the south, west, and east, were categorized as primary wildlife areas, while the Moquah Barrens RNA was categorized as a secondary wildlife area. This agreement was replaced by a 1965 agreement that established the Moquah Barrens Wildlife Management Area (WMA), primarily for sharp-tailed grouse management (Yurich 1965). The Moquah Barrens RNA is on the eastern edge of the Moquah Barrens WMA (Fig. 2). While the WMA was not related to the established purpose of the RNA, it becomes important later in the RNA's timeline.

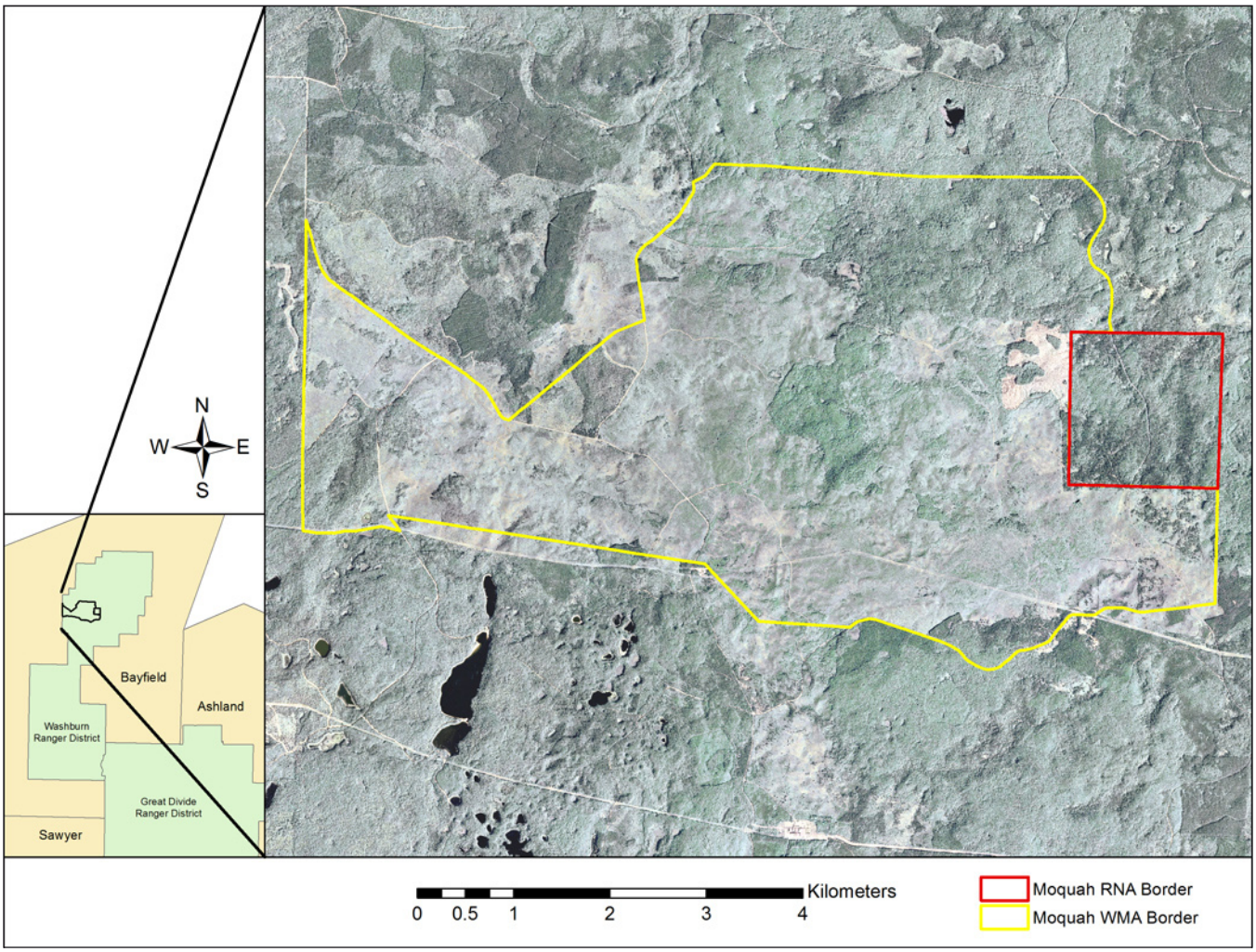


Figure 2.—Moquah Barrens Research Natural Area established in 1935 (area inside red border) and Moquah Barrens Wildlife Management Area established in 1965 (area inside yellow border). Background imagery from 2013 National Agricultural Imagery Program (NAIP) aerial photograph.

Decision to Disestablish Moquah Barrens RNA

In May of 1956, the Regional Office[4] formally asked the Director of the Lake States Forest Experiment Station, with a copy to the CNNF, whether the Moquah Barrens RNA should remain as a RNA or be placed under management (Svensen 1956) (Fig. 3). The Station Director asked the CNNF to inspect the area and provide a recommendation about whether to retain the Moquah Barrens RNA as a natural area or to put it under management (Dickerman 1956a) (Fig. 4). In the request, the Station Director noted that: (a) the Station and the Regional Office had no records of any action taken to implement the 1934 working plan (Shirley 1934); and (b) if the CNNF wanted to retain the RNA as active, the CNNF would need to send the Station a layout of observation points so that the Station could make measurements (i.e., implement the 1934 working plan) (Dickerman 1956a). The CNNF's response was: "My recommendation is to formally release Sec. 23, T48N, R7W, so that it can be handled by the Chequamegon the same as other National Forest land in the area" (Ralston 1956) (Fig. 5). The Station Director concurred with this recommendation and informed the Regional Office: "Our recommendation is that the area be abandoned as a Natural Area and placed under management by the Chequamegon National Forest" (Dickerman 1956b) (Fig. 6). We note that the correspondence about the disestablishment was only found in the Station's records; none was found in the CNNF file.

In 1960, the Deputy Assistant Chief of the Forest Service sent out a memo to all Station Directors asking for an update on all natural areas (Jemison 1960). The Lake States Station responded with the following regarding Moquah Barrens RNA: "Our records show that this area was formally set aside for a joint study by the Region (9) and the Station, but that the proposed study (ecological change following burning in 1935) was never started. In 1956, the Station recommended to Region 9 that it be abandoned as a natural area, but we have no record of further action by the Region" (Dickerman 1960). In 1967, the Assistant Station Director (Z. Zasada) sent a memo to the CNNF (not retained in the Forest's files) expressing surprise that Moquah Barrens was included in the timber management plan as a RNA, noting that the CNNF agreed to abandon the RNA in 1956 (Zasada 1967). The Station's letter also states "Please let us know your plans for the area. We will want to correct our records if you plan to keep it as a natural area. If you plan to close out the area, we will be glad to assist in preparing a disestablishment report" (Zasada 1967). There was no response to the Station but the Regional Office (which was copied on the Zasada 1967 memo) responded to the CNNF with a copy to the Station: "Turning the Moquah Area over to the Washburn District does not settle the issue. Do you want to disestablish the Moquah Natural Area? If so, it will require a formal proposal to the Chief. Research apparently will do this if you give them the go-ahead" (St. Amant 1967). There is no record of any direct response by the CNNF to the Station or the Regional Office regarding the St. Amant (1967) memo. The original establishment document that is in the Station's records has the following handwritten note (initials ER, dated 7/8/66): "Abandoned as per recommendation of Cunningham to Reg. Forester R-LS, Natural Areas 6/5/56".

CNNF Changes the RNA's Objectives

In early 1968, the CNNF sent a memo to the Regional Forester (Trochlil 1968) (Fig. 7) observing that the Station no longer had an interest in the area—but omitting that the CNNF had concurred with this assessment. It is unknown if Trochlil (1968) wrote in response to St. Amant (1967), but the April 1967 letter from the Station referenced by Trochlil (1968) is likely Zasada (1967) (see above). Trochlil (1968) states that the CNNF wanted to continue the RNA classification of the land if possible, with a new management objective: "to leave the area alone as has been done during the last 33 years." (Fig. 7). This was a change from the sentiment expressed by the CNNF in 1967 to put the RNA back into management (see above). It marked a fundamental shift away from the scientific reasoning and land management objectives used to establish the Moquah Barrens RNA. It also set the stage for the RNA's pine barrens ecosystem to be lost.

STANDARD FORM NO. 64 Forest Service, R-9 Milwaukee 3, Wisconsin

Office Memorandum • UNITED STATES GOVERNMENT

TO : Director, Lake States Forest Experiment Station DATE: May 8, 1956

FROM : H. A. Svensen, Assistant Regional Forester

SUBJECT: U - CLASSIFICATION, Moquah Natural Area

FOREST REC MAY 9 - 1956 LAKE STATES FOREST EXPERIMENT STATION

In 1935 the Moquah Natural Area containing 640 acres, Section 23, T 48 N, R 7 West was established by the Chief. The stated objective for the area was to determine what will naturally take place on this area. The study was to be carried on jointly by the Forest and your Station.

As far as we know no action has ever been taken on this study and the question has come up as to whether the area should be retained in its natural state or whether it should be placed under management. We would appreciate your comments.

H. A. Svensen

cc - Chequamegon

JHS

Figure 3.—May 8, 1956, memorandum from Region 9 to the Lake States Forest Experiment Station with a carbon copy to the Chequamegon National Forest, asking for comment on a change in status for the Moquah Barrens Research Natural Area.

Northern Lakes May 16, 1956

M. B. DICKERMAN, Director ROBERT D. McCULLEY, Acting

R-LS NATURAL AREAS Moquah

We have a memorandum dated May 8 (U - CLASSIFICATION, Moquah Natural Area) from Svensen in the Regional Office requesting our review of the status of the Moquah Natural Area in the Chequamegon National Forest. This is an area of 640 acres set aside in 1935 for a study to be carried on jointly by the Forest and the Lake States Forest Experiment Station. The area involved is Sec. 23, T. 48 N., R. 7 W.

So far as our records indicate, and those of the Region, there has been no action on the proposed study. Shirley wrote up some specifications for transects and observational plots which were to be remeasured periodically to record ecologic changes. It is logical to expect that if natural areas are to be maintained in an active status by the Station there should be such a system of observation points to tell us what is happening under natural conditions.

We would like to have you look over this area and give your recommendation on its disposition. If you recommend retaining it in its present status, we will expect to receive the proposed layout of observational points which will allow us to maintain a record of vegetational changes.

We hope that you will be able to make your inspection of the area and report to us by June 1 so that we can send our reply to the Regional Forester.

ROBERT D. McCULLEY

c - Regional Forester

RDMcCulley:HW

Figure 4.—May 16, 1956, memorandum from the Lake States Forest Experiment Station to the Chequamegon National Forest (with a carbon copy to Region 9) requesting an evaluation of whether to maintain the RNA designation for the Moquah Barrens Research Natural Area.

STANDARD FORM NO. 64

Lake States Forest Experiment Station
Northern Lakes Forest Research Center
P. O. Box 67
Wausau, Wisconsin

Office Memorandum • UNITED STATES GOVERNMENT

TO : DIRECTOR LSFES

DATE: May 29, 1956

FROM : R. A. Ralston, Forester in Charge

SUBJECT: R-LS NATURAL AREAS Moquah

FOREST SERVICE
MAY 31 1956

Please refer to R. McCulley's memorandum of May 16, 1956.

Your records are correct regarding past action on this proposed study -- apparently, nothing was ever done.

On May 28th, Bill Paddock, Henry Jacobs, and Jack Horner of the Chequamegon and I examined the area. It is mainly young jack pine, aspen, and scrub oak with some open areas and frost pockets.

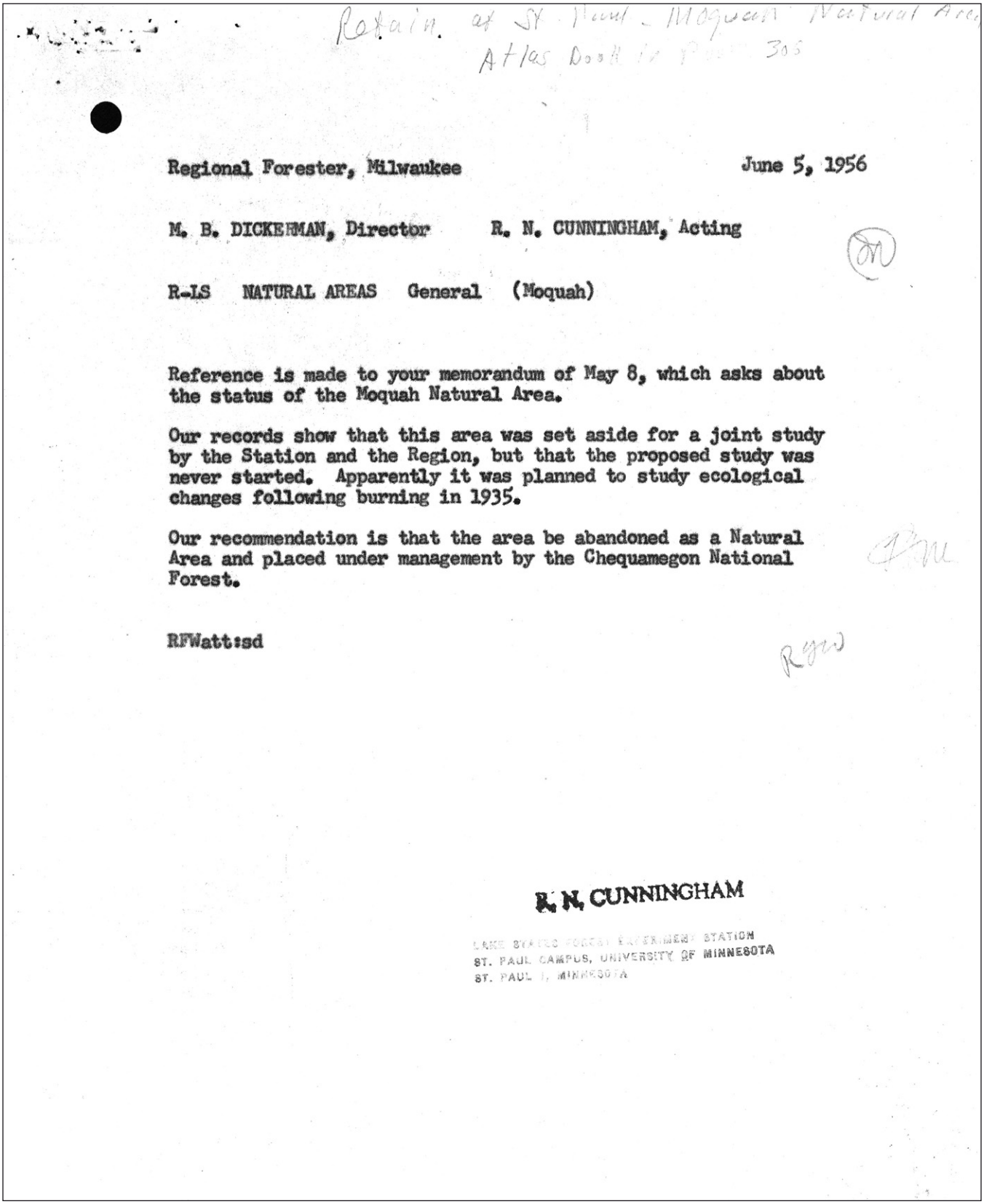
The area burned over just prior to 1935 and I assume that this was the main reason it was tentatively selected as a study area.

It would have been interesting to have an ecological record during the past twenty-odd years. However, this was not accomplished.

My recommendation is to formally release Sec. 23, T48N, R7W, so that it can be handled by the Chequamegon the same as other National Forest land in the area.

R. A. Ralston

Figure 5.—May 29, 1956, memorandum from the Chequamegon National Forest to the Lake States Forest Experiment Station recommending formal release of the Moquah Barrens Research Natural Area to general land management status.



Retain at St. Paul - Moquah Natural Area
Atlas Book in Part 305

Regional Forester, Milwaukee

June 5, 1956

M. B. DICKERMAN, Director R. N. CUNNINGHAM, Acting

R-LS NATURAL AREAS General (Moquah)

Reference is made to your memorandum of May 8, which asks about the status of the Moquah Natural Area.

Our records show that this area was set aside for a joint study by the Station and the Region, but that the proposed study was never started. Apparently it was planned to study ecological changes following burning in 1935.

Our recommendation is that the area be abandoned as a Natural Area and placed under management by the Chequamegon National Forest.

RFWatt:sd

R. N. CUNNINGHAM

LAKE STATES FOREST EXPERIMENT STATION
ST. PAUL CAMPUS, UNIVERSITY OF MINNESOTA
ST. PAUL 1, MINNESOTA

Figure 6.—June 5, 1956, memorandum from the Lake States Forest Experiment Station to Region 9 stating the recommendation from the Forest and the Station to change the status of the Moquah Barrens Research Natural Area from natural area to general management.

FORM 6200-8 (1/64)
UNITED STATES GOVERNMENT

Memorandum

Department of Agriculture---Forest Service
Chequamegon National Forest
Park Falls, Wisconsin 54552

TO : Regional Forester, R-9 File No. 4060

FROM : RICHARD C. TROCHLIL, Lands Staff Officer Date: March 12, 1968

SUBJECT: Research Facilities - Natural Areas Your reference:

We have on this Forest a section of land known as the Moquah Barrens Natural Area. Apparently this 640-acres was set up in 1935 to study the natural ecological succession following wildfire. However, no study was ever made. In 1956, the former Lake States Experiment Station formally stated that they no longer had an interest in the area.

Another letter from them in April of 1967 (copy attached) indicates that we still have the option of retaining this as a natural area. As far as we can determine, this area has been managed under Reg. U-4 as a research natural area. We would like to continue this classification even though no research is presently taking place. Our plans are to leave the area alone as has been done during the last 33 years and continuing the U-4 regulation looks like the best way of doing this.

Can we continue the classification of this area under Reg. U-4 even though there is no active research taking place at the present time?

cc: Washburn

Richard C. Trochlil

F.S. R-9 RECEIVED MAR 14 1968 CHEQUAMEGON NATIONAL FOREST WASHBURN, WIS. Ans:

Figure 7.—March 12, 1968, memorandum documenting the change in objective for the Moquah Barrens Research Natural Area.

During the time period in which this decision was made, there was a paradigm shift occurring in the scientific community from an equilibrium view of ecosystems to a non-equilibrium view (Ricklefs 1973). This shift was informed by the evolving understanding of the role of fire. As early as 1910, researchers were discovering that fire was an important factor determining forest composition (Ahlgren and Ahlgren 1960, Donovan and Brown 2007). In the 1930s, experiments using prescribed fire were done in southern longleaf plantations to understand how to improve the establishment, growth, and maintenance of the pine stands (Hardtner 1935). Observational work in Canada (Maissurow 1935) documented the importance of fire for successful reproduction of white pine. Work on the effects of fire continued and by the early 1960s, fire was understood as a primary driver of some forest systems, including the barrens ecosystem (Ahlgren and Ahlgren 1960). Indeed, specific to the Northwest pine barrens of which the Moquah Barrens RNA is part, Curtis (1959) wrote: "there is no doubt that the immediate cause of the pine barrens is fire." (p. 342) and further goes on to say:

> "Not only the grouse harvest but the blueberry crop as well have become victims of the bureaucratic dictum, that since most forest fires are the source of economic loss, therefore all fires are bad and must be prevented at any cost. This dogma has been supported by such an intensive propaganda campaign that there is danger of its being accepted as truth. On the contrary, the facts plainly indicate that fire is a normal environmental influence in the life of the forest; the evolution of such fire adaptations is clearly shown by the serotinal cones of jack pine. Fires have been burning in northern Wisconsin for at least 10,000 years and will continue to burn for another 10,000 unless artificially stopped … On the other hand, controlled fire, burning when and where desired, can be used as a valuable tool in both silvicultural and game management operations. Such use should be actively encouraged and promoted, rather than hindered by outmoded taboos, to the end that the health and well-being of our forests and other nonagricultural lands can be raised to their optimum levels." (p. 344)

The CNNF had started using prescribed fire in 1965 to manage for sharp-tailed grouse habitat in the adjacent Moquah Barrens WMA (e.g., Yurich 1966). Furthermore, the revisions to the Forest Service Manual allowed for management activities, such as prescribed fire, to maintain the natural condition of RNAs. In June 1966, the Chief of the Forest Service sent out a memo about a revision to Forest Service Manual chapter 4060, which deals with Research Natural Areas (Cliff 1966). The revision clarified that management activities, such as prescribed fire, could be used to maintain the natural condition of a RNA: "Research Natural Areas will be retained in a virgin or unmodified condition except where measures are required to maintain a plant community which the area is intended to represent" (Experimental Areas and Research Natural Areas 1966). While the CNNF knew about the importance of fire to the pine barrens ecosystem, and knew about Curtis' (1959) work (Germain 1975), upper management did not apply that knowledge to the Moquah Barrens RNA.

External Designations Make Additional Changes to the RNA's Objective

In the 1970s, the RNA received two external designations. The first was designation as a Wisconsin State Natural Area in 1970. In 1967 the WDNR informally discussed with the CNNF the possibility of making the RNA an official Scientific Natural Area (SNA). In a follow-up letter, Germain (1968) said that the State's interest in the RNA was for it to be managed for fire exclusion, in order to compare with State areas that use management to maintain savannas. In 1969, Germain provided the CNNF with a SNA application for approval (Germain 1969). On the SNA application, the stated objective of the Moquah Barrens RNA was "to allow vegetative succession with no management other than the prevention of fire." This omits the RNA's original purpose—to learn how quickly commercial species would re-establish in the absence of fire. The application then states "Propose that this management objective continue so that this area can be used to compare studies with other areas where fire is used intentionally to preserve the savanna state." The CNNF sent the application to the Regional Office for approval without change (Rollens 1969),

implicitly agreeing with the new objective for the RNA as a comparison site for restoration activities.

When the Regional Office sent the application to the Station for processing (King 1969), it is a puzzle why the Station did not raise questions about this proposed designation, given the disestablishment recommendation that the Station and CNNF had jointly made earlier. Recall that just 2 years earlier in 1967, the then-Assistant Director of the Station, Z. Zasada, had raised questions about the contradiction between the CNNF Forest Plan and the mutual decision to disestablish the RNA. McNasser, the Station's Assistant Director in 1969, wrote to the Chief of the Forest Service stating that the Regional Office had no records of disestablishment and that the Washington Office should not have taken Moquah Barrens RNA off their list of natural areas (McNasser 1969). It appears likely that because of this letter, the Washington Office put the Moquah Barrens RNA back on the official list of natural areas. This would explain why the Forest Service Research Natural Area Committee established the Moquah Barrens RNA officially as a Research Natural Area in 1975 (Byers 1975; note the documents that Byers mentions in the December 5, 1975, letter—a 4060 Research Memorandum signed by L.K. Kelley and minutes from the January 15, 1975, Research Natural Area Committee Meeting—have not been preserved by the Forest or the Station).

The second external designation was for Department of the Interior National Natural Landmark status. The application for this was done by the CNNF (Byers 1973). The National Natural Landmark application used the significance of the area as stated by the Wisconsin State Scientific Areas Preservation Council as a reason for Natural Landmark status, and used the objectives from the State Natural Area application in the statement that the "area could be used for comparison studies and scientific use" though the application also states "No research has been conducted." The resulting National Natural Landmark evaluation study (Brooks 1977) noted that although the area was not natural because of the fire protection afforded over the previous four decades, the area might have value for demonstrating how the lack of fire could affect the natural fire-dependent system (i.e., as a comparison to areas, such as the WMA, that were managed with fire). However, Brooks (1977) noted that the only threat to the RNA was the continued fire suppression, which would result in the conversion of the system to a jack pine and aspen forest. Thus, Brooks (1977) recommended as a special condition that the management plan should be reviewed "20-60 years from now" to determine if prescribed fire should be used to maintain the area as a jack pine barrens ecosystem. After consideration of the brief prepared by Brooks (1977) and an update by the Forest (Byers 1979), Secretary of the Department of Interior Cecil D. Andrus approved the Moquah Barrens RNA as a National Natural Landmark in March 1980 (Andrus 1980). While the Natural Landmark Brief states that the Moquah Barrens is an excellent representative of the pine barrens, a vanishing ecosystem due to intensive fire protection, it also states in the special conditions: "as a result of fire suppression since the 1930s, this site is succeeding to forest and the barrens will inevitably vanish. It is important to locate and designate a second site elsewhere as a replacement where fire can be used to maintain barrens."

In 1993, the Moquah Barrens RNA was identified as a threatened or damaged National Natural Landmark due to 60 years of fire suppression that had resulted in the loss of the jack pine-scrub oak barrens community (Loach 1993). This was the outcome predicted by Brooks (1977). The Forest Service response came from the North Central Experiment Station (Tyrrell 1994). In that letter, the Station does not dispute the loss of the barrens system but states that fire exclusion was intentional to allow the RNA to be used for comparison studies and that such a study was ongoing. The Moquah Barrens RNA was later removed from the threatened or damaged list; a 1998 National Natural Landmark report marked its condition as "satisfactory" with "no action needed" (Christensen 1998). This change may be due to the 1993 report being based on a site inspection by the National Park Service while the 1998 report was based on a CNNF-provided condition assessment communicated over the phone to the National Park Service (Christensen 1998).

Management and Recreation Activity

Starting in the 1960s, management was documented within the Moquah Barrens RNA more often than the previous decades, though it was minimal due to the protected nature of the RNA. Documentation of public use of the RNA came with its designation as a Wisconsin State Natural Area. WDNR Scientific Area Annual Reports during the early 1980s noted that many educational groups used the area along with many hunters, berry pickers, and bird watchers. By 1985, the number of recreational users dwindled to a few berry pickers and rare campers (Eilertsen 1985). During the 1990s and 2000s, there were few activities of any kind within the Moquah Barrens RNA. Details of the management and recreational activities are in appendix 2.

RESEARCH ACTIVITIES

A common theme in the administrative record is that the Moquah Barrens RNA was important for Forest Service science. Nonetheless, no peer-reviewed scientific articles have been generated by research conducted on the RNA. This section documents the research and monitoring projects that were carried out on the RNA.

Forest Service

Vegetation succession study

In 1979, Forest Stearns and Christopher Dunn (University of Wisconsin-Milwaukee), under a research agreement with North Central Forest Experiment Station, set up 12 vegetation plots on the RNA (Dunn and Stearns 1980). In 1990, all 12 vegetation plots from that study were located but not measured; some were re-marked using wooden stakes (U.S. Forest Service 1990). In 1996, all 12 vegetation plots were located and measured but not re-marked (Crow 1996, Donoghue 1996); this is the study referenced in Tyrell's (1994) response to the National Landmark Coordinator.

Because the plots were neither re-marked nor assigned GPS coordinates in 1996 (Sheehan 1996), geographic information system (GIS) software (ESRI 2010) and the written descriptions of the plot locations were used to estimate the plot locations. Only 3 of the 12 original vegetation plots were located over three visits to the RNA. One was already known and maintained by the CNNF; another was apparently re-marked with a plastic stake by unknown persons (decomposing wooden stakes were found nearby). The wooden posts used in 1979 and 1990 had decomposed, leaving no traces. Indeed, Dunn and Stearns (1980) had observed that a number of posts had been destroyed by bear activity within a year of being established and recommended that the plots be re-marked with metal posts.

As of 2015, no peer-reviewed scientific papers based on the vegetation plot data have been published. The data from both sets of plot measurements were recently published (Byers et al. 2015); the data publication includes a copy of the Dunn and Stearns (1980) report.

CNNF permanent vegetation plots

In 1990, 82 permanent vegetation monitoring plots were set up across the Forest by the CNNF staff as a long-term ecological monitoring system (Vora 1997). The four plots located in the RNA have been measured three times (1990, 1996, and 2008-2009); one plot was also measured in 2003. These data are not yet publicly available but can be obtained from the CNNF.

CNNF FIREMON plots

The Moquah Barrens RNA is a part of the CNNF's Fire Effects Monitoring and Inventory System (FIREMON). There are two plots located within the RNA that were established in 2011 and 2012. These data are not yet publicly available but can be obtained from the CNNF.

Landscape structure and temperature relationships study

This study (Chen 1994) placed a temporary weather station in the RNA. The RNA weather station simply provided a reference temperature series under a closed canopy for the study's actual focus on temperature relationships in the barrens area near the RNA. A research article was written by Saunders et al. (1998); the fate of the associated data is unknown.

State of Wisconsin

After the Moquah Barrens RNA was designated as a State Natural Area, the State established photographic points and sponsored two biological surveys within the RNA.

Photographic points

In July 1973, seven permanent photographic points were placed within the RNA by the Wisconsin Scientific Areas Preservation Council in an attempt to monitor long-term vegetation changes (Read 1973). A second series of photographs at these points was taken in 1978.

GIS software (ESRI 2010) and the written descriptions of the site locations were used to estimate the photo point locations. Over three visits to the RNA, five of the original seven points were located. Although the metal U-channel stakes were originally painted white, the stakes were often covered with rust, making them difficult to find. We speculate that the two remaining stakes were buried under vegetative cover or fallen trees.

The WDNR and the Forest Service Research Data Archive collaborated to publish these WDNR photographs and documentation from the 1973 series (WDNR 2015b). The publication also includes all photos and documentation from the 1978 series, except for photo points 3 and 4, which were not retained by the WDNR. The global positioning system (GPS) locations for the located points are included, as well as the estimated locations for the other two points.

Breeding bird surveys

From 1971-2006 the WDNR, with the cooperation of the Wisconsin Society for Ornithology, conducted annual breeding bird surveys across the State, including in the RNA. The WDNR and the Forest Service Research Data Archive collaborated to publish the data from just the Moquah Barrens RNA transects (Mossman et al. 2015); this data publication includes an early WDNR analysis of the statewide data (Mossman 1980).

Moths of Wisconsin

In 1992, a study was conducted to create the first comprehensive statewide list of Wisconsin's moths (Ferge and Balogh 2000). Leslie A. Ferge was granted permission by the WDNR State Natural Areas Program to collect specimens in the Moquah Barrens RNA; specimens were deposited in the Milwaukee Public Museum (Holtz 1992).

FUTURE DIRECTIONS

Based on what we learned through the archiving process, we first offer some ideas about the future of the Moquah Barrens RNA, and then some thoughts on how to improve administrative management of RNAs in general.

Options for Moquah Barrens RNA

In the 1930s, the mission of the national forest system was to provide a sustainable timber supply in contrast to the more standard timber company practice of cut and abandon (Rutkow 2012). Thus, in its original context, the research question for the Moquah Barrens RNA was essentially "can commercially useful trees re-establish themselves quickly enough to avoid the expense of intentional planting and care?" (per above, the RNA was originally to serve as a "check and comparison with adjoining and recently established plantations"). The question probably needed only 5 to 15 years to answer; if establishment had not yet happened in that time frame, natural establishment would not provide the desired commercially viable timber source. That, in turn, would demonstrate that planting was economically justified. The project has now had an unintended run of roughly 80 years. Based on the extant record and our visits to the site with CNNF personnel, there has been no establishment of the hoped for commercially useful trees. What has been established is that natural processes (as conceived in the 1930s) in a pine barrens ecosystem will not produce trees that are considered commercially useful. Indeed, in the context of our current understanding of the role of fire in structuring ecosystems, the study became scientifically obsolete many years ago.

Looking forward, we believe there are three primary management options the CNNF and Northern Research Station could consider pursuing for the Moquah RNA:

1) Stay the course – maintain fire suppression indefinitely to retain consistency with over 80 years of history.
2) Revitalize the RNA – retain the area as a research natural area but update the purpose.
3) Disestablish the RNA – implement the plan agreed to by the Forest and Station in 1956 and return the area to regular management.

The first option of staying the course sets the area aside as homage to fire-suppression policies of a bygone era. The drawbacks of this option include not being aligned with U.S. Forest Service policy on what constitutes a research natural area, the continued loss of the endangered ecosystem the RNA was ostensibly set aside to preserve, and increased risk of severe fire from fuel loads accumulated over 85 years. The vegetation data that have been collected on the RNA document the change from a pine barrens to a forest of aspen and dense jack pine. During site visits, we observed substantial accumulation of fine fuels (i.e., needles and leaves), and larger fuels from dead jack pine and aspen limbs, which could form ladder fuels when extended to the ground[5] (ladder fuels help a fire move into the forest canopy).

The second option of revitalizing the RNA would allow the CNNF to restore and maintain the original pine barrens ecosystem. This management action would bring the area back into alignment with U.S. Forest Service research natural area policy and its National Natural Landmark status, allow for some integration with the objectives of the neighboring Wildlife Management Area, and offer opportunities for research during restoration efforts. With long-term suppression of fire and no other timber management, the RNA is a unique parcel of land in the CNNF and is likely not replicated elsewhere due to local landscape conditions (Nowacki and Abrams 2008), creating opportunities to study the system prior to applying treatments. There is an opportunity to investigate whether the "mesophication process" (where fire-adapted floras are progressively lost to shading, competition, and preferential herbivory, which causes the understory and forest floor condition to become increasingly mesophytic) has gone on too long and is now irreversible regardless of reintroducing fire (Abrams 2005, Nowacki and Abrams 2008).

The third option of disestablishment provides maximum flexibility for developing new management directions. Possible new management objectives include: (a) restore the area to a pine barrens; (b) formally integrate the area into the neighboring Wildlife Management Area; (c) attempt to convert the area to red pine savanna, bearing in mind that natural regeneration of red pine is not well understood[6] (as noted above, red pine savanna was part of the original vegetation community in the area); and (d) create an experimental area for responding to effects of climate change on northern forests. Objectives c and d might be facilitated by converting the area to an experimental forest. Even the "simple" restoration objective of option 2 might be facilitated in the near term by a status conversion to experimental forest.

Management under either revitalization or disestablishment allows the CNNF managers to initiate a significant project consistent with the Forest Service Chief's goals of restoration and wildland fire management (Tidwell 2014a, 2014b; U.S. Forest Service 2015). If retaining Moquah Barrens' RNA status is the strategic path selected, there is precedence for using fire for restoring the system; other National Forests have reintroduced fire to maintain RNAs' natural local systems (Evenden et al. 2001, Greene and Evenden 1996, U.S. Forest Service. [N.d. a.]), in accordance with the National Research Natural Areas Strategy (U.S. Forest Service 1993) and FSM 4063 (U.S. Forest Service 2005). Indeed, due to long histories of fire suppression on other RNAs,

[5] Personal communication from Matthew Bushman, Botanist, Chequamegon-Nicolet National Forest, Washburn Ranger District, Washburn, WI.

[6] Personal communication from Volker Radeloff, Professor, Department of Forest & Wildlife Ecology, University of Wisconsin, Madison, WI.

the introduction of prescribed burning to restore the desired vegetation has had to be preceded by vegetation management activities targeted at reducing the risk posed by ladder fuels (Evenden et al. 2001).

In addition, once the pine barrens system has been restored, the Moquah Barrens RNA could function as a reference site for the adjacent Moquah Barrens Wildlife Management Area (where multiple types of management actions are practiced). Restoring the RNA has the potential to renew a management-research partnership and contribute to the long-term viability of a Wisconsin-endangered ecosystem (WDNR 2015a). Such a partnership could improve understanding of fuel accumulation and fire severity impacts to second-order fire effects such as regeneration, soil nutrients, and seed bank of barrens-adapted species, which have implications for long-term sustainability of sharp-tailed grouse, pollinators, and other at-risk biota of this system (Fandel and Hull 2011). It could also provide a comparison to a recent study on the effects of 54 years of fire suppression in the pine barrens of central Wisconsin (Li and Waller 2015).

Administrative Management of RNAs

One clear conclusion from our work to archive data from the Moquah Barrens RNA is the importance of institutional memory to long-term projects. There are three components to institutional memory for the RNA. First, over time both the CNNF and the Station leadership experienced turnover in personnel that led to key decisions made about the RNA being forgotten. Second, the loss of people-based institutional memory was compounded by the loss of records-based institutional memory—the records that documented the multiple points in time that the CNNF had decided to return the RNA to a managed state. Third, there may have been a deterioration of contextual institutional memory—employees passed along the knowledge that the RNA's long-term project included exclusion of fire, but the context (i.e., the reason) for the exclusion was not passed along. Thus, the loss of institutional memory across different levels and parts of the Forest Service resulted in contradictory decisions and management actions over the years. The breakdowns in institutional memory also hindered our attempt to reconstruct the RNA's history.

Two steps appear to be useful for RNA management. The first step involves improving records management; the second step involves broader process improvements.

The current records schedule for RNA documents directs the Forest Service to send the records to the National Archives and Records Administration after 10 years (U.S. Forest Service 2014). Simple compliance with this direction creates problems for informed management of the long-term project that is a RNA because it creates a loss of readily accessible information about the project at the Station and Forest levels. We suggest a better approach would be to retain digital copies of RNA records and place those copies in a common repository available to everyone involved with RNA management—RNA coordinators, relevant resource managers, Station/Forest/Region executives, and so on. Such a strategy is consistent with modern records management practice[7], and is being used by at least one Forest Service experimental forest. The Forest Service has multiple options to implement such an approach. Two feasible options would be an internal web site or a Microsoft® SharePoint site, as these options make it easy to interleave explanatory text, photos, video, etc. with the formal records.

The long-term nature of RNAs leads us to suggest that formally thinking about RNAs as long-term ecological projects would help improve records management and administration. Sutter et al. (2015) present guidelines for program management of long-term ecological projects, including many of the project administration activities needed for success. The guidelines lay out management stages of planning, implementation, analysis, preserving/sharing, and evaluation. These translate well to RNA projects. For example, the establishment report for the Moquah Barrens RNA

[7] Personal communication from Monica McGee, Agency Records Officer, U.S. Forest Service, Washington, DC.

did not state a time-to-review point for the Moquah Barrens study. Nonetheless, the 1956 review of the RNA provides an instance of the evaluation stage of good program management. The 1956 evaluation was successful; however, there was a failure to follow up with the planning stage of the cycle. This failure seems to have been due to a lack of documentation about who had responsibility to carry through the decision to disestablish. In addition, there was no quality assurance process in place to ensure that the necessary actions were successfully executed and there appears to have been no plan regarding what would be done with Moquah Barrens RNA after the proposed disestablishment. Adopting a more structured project management approach suitable for long-term projects (Sutter et al. 2015) is likely to greatly reduce the probability of other RNAs inadvertently becoming as degraded as Moquah Barrens RNA.

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APPENDIX 1

Investigation of the 1936 Fire and Salvage Logging

William Byers (Chequamegon National Forest, Park Falls Ranger District) mentioned to the WDNR Scientific Areas Preservation Council (Byers 1971) that "A long time employee, now retired, of the Washburn Ranger District recalls, from memory only, that the entire Natural Area was burned in the big fire of August 1936. He also stated that some of the red pine was salvage-logged that fall by the CCC's (sic) [Civilian Conservation Corps]. These trees were used to construct the shelter at Mount Valhalla. Written confirmation of these remembrances cannot be found."

In 1994, Duane Kick (Chequamegon National Forest, Washburn Ranger District) asked the WDNR about the 1936 fire (St. Onge 1994) and was sent the October 16, 1936 fire report. The map enclosed with the report indicates the fire was well south of the Moquah Barrens RNA, though St. Onge wrote on the map: "Probable final fire size and shape based on conversations with Dewey Armbruster retired Iron River Forest Ranger. Actually this is a bit small for the 22 thou estimate." A 1938 aerial photo-composite of the affected area indicates that the map is likely correct in the extent of the fire and it does not appear that the Moquah Barrens RNA was affected by the 1936 fire (Fig. 8). Regarding CCC activity, since there was no fire in the summer of 1936, there could not have been "salvage-logging" in the fall of 1936.

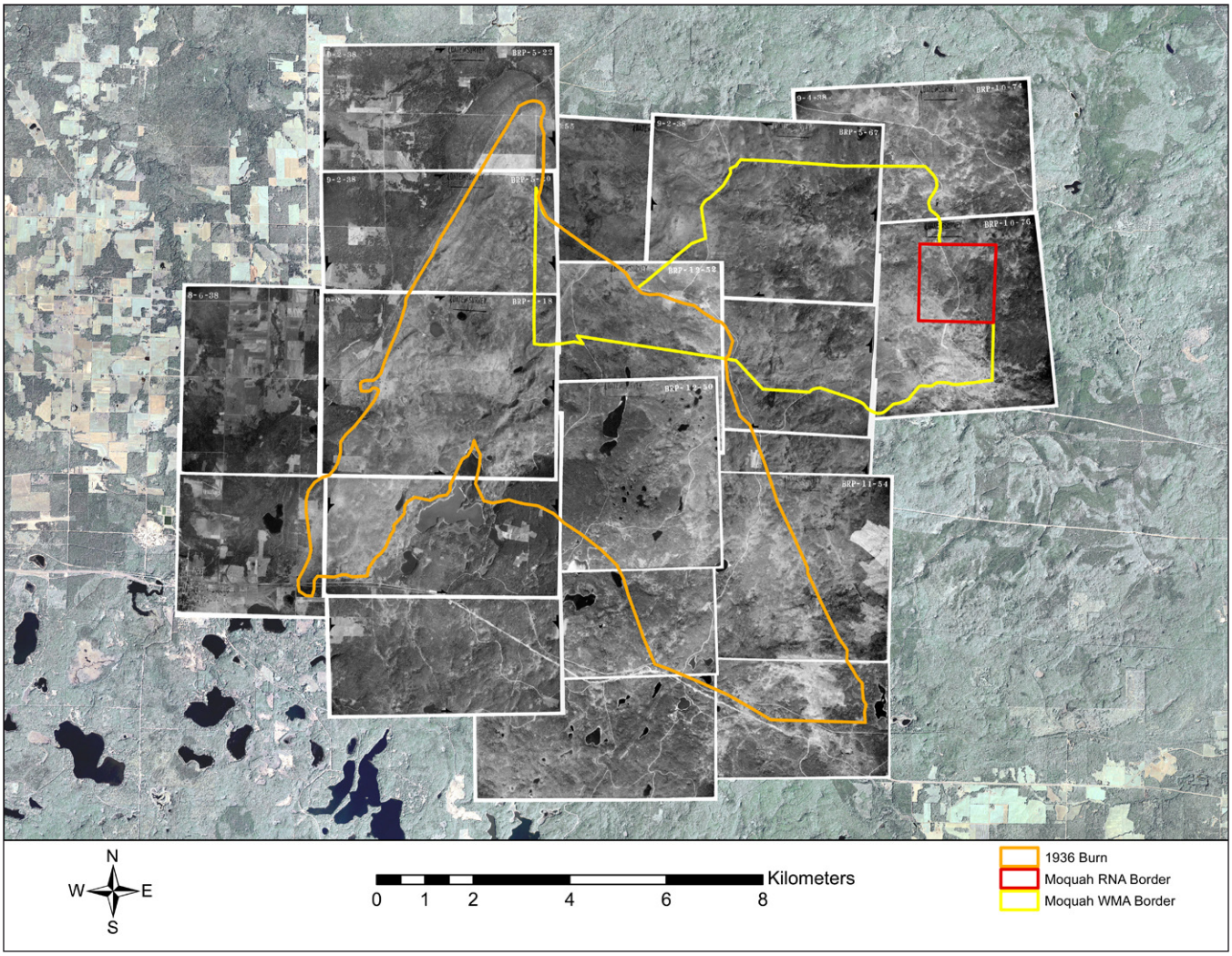

Figure 8.—Composite of 1938 aerial photographs showing the putative 1936 burn area provided by St. Onge (1994). The 1938 aerial photographs are available at Wisconsin Historic Aerial Image Finder (http://www.sco.wisc.edu/whaifinder/whaifinder.html).

APPENDIX 2

Description of Management and Public Use Activities on Moquah Barrens Research Natural Area

Starting in the 1960s, management activities were documented within the Moquah Barrens RNA more often than the previous decades. As a follow-up to the Moquah Barrens RNA being listed as a State Natural Area, Tans (1971) asked the CNNF for any records on fire history, logging, or the "effects of man." Byers (1971) stated that based on a retired employee's recollection, the CNNF thought a fire might have burned the Moquah Barrens RNA and resulted in salvage logging (see appendix 1 for details). Byers (1971) also noted that in 1960 or 1961, unplanned management occurred when a State of Wisconsin Youth Camp group accidentally cut two brush piles worth of material just off the southwest corner of the Natural Area. In 1964, Forest Road #236, which bisects Section 23, was widened and rebuilt, which disturbed the adjacent vegetation (Byers 1971). Responding to a questionnaire from the WDNR Scientific Areas Preservation Council regarding use of the RNA in 1971, it was noted that an informational sign had been ordered to be placed along Forest Road 236 for public information, and there were plans to mark the boundaries of the RNA on the ground (Byers 1972). In mid-1973, the RNA was closed to all motorized vehicles due to the application for National Landmark Status (U.S. Forest Service 1973).

Further management of the RNA was requested in the 1980s. Recommended improvements included officially marking boundaries, creating a permanent firebreak between the RNA and the area of the Moquah Barrens WMA immediately south of the RNA where prescribed burns were allowed, and relocating the dirt road on the southern end of the RNA that intersects Forest Road #236 (U.S. Forest Service 1980, Eilertsen 1985).

In October 1988, these recommended improvements were addressed in the Moquah Barrens Opportunity Area Analysis Report and Environmental Assessment, which included both the Research Natural Area and Wildlife Management Area. Public support was great for keeping the RNA in its natural state, which helped management select the alternative that best preserved the "natural character" through the minimization of all visitor use impacts since no vegetative manipulation of the area was allowed (Eilertsen 1988). This alternative established a marked boundary for the RNA, constructed a parking lot at the RNA sign, continued to restrict motorized vehicles, and increased education about and enforcement of closure notices (U.S. Forest Service 1988).

During the 1990s and 2000s, there were few management activities within the Moquah Barrens RNA. An annual RNA check-up form in 1994 (Kiewit 1994) noted that the information sign needed to be changed to reflect current vegetation within the RNA and that the boundary should be surveyed and marked, since it had not been completed following the recommendations of the Moquah Barrens Opportunity Area Analysis Report and Environmental Assessment from 1988 (U.S. Forest Service 1988). The check-up also noted that all roads other than Forest Road #236 should be closed, echoing sentiments from previous decades that motorized vehicle use should be strictly limited within the RNA. There are no other annual check-up forms in the Forest's Moquah Barrens RNA file.

Documentation of public use of the RNA came with its designation as a Wisconsin State Natural Area. For example, 225 members of the public had used the RNA in 1971 for botanical studies, hunting, berry picking, and school trips (Byers 1972). WDNR Scientific Area Annual Reports during the early 1980s noted that many educational groups were using the area along with many hunters, berry pickers, and bird watchers. The reported impacts from recreational users were few and generally limited to blueberry picking (U.S. Forest Service 1980). By 1985, the number of recreational users dwindled to a few berry pickers and rare campers (Eilertsen 1985). There is no formal documentation of recreational activity in the RNA during the 1990s and 2000s. The Natural Resources

Research Institute, University of Minnesota-Duluth, has surveyed a cluster of bird survey sites immediately adjacent to the RNA starting in 1992.[8] The Chequamegon-Bay Birding and Nature Festival has sponsored a field trip to the Moquah Barrens RNA to document migratory birds since 2006, when the festival was started.[9]

[8] Personal communication from Linda Parker, Forest Ecologist, Chequamegon-Nicolet National Forest, Park Falls, WI.

[9] Ibid.

Ribic, Christine A.; Rugg, David J.; Donner, Deahn M.; Beck, Albert J.; Byers, BJ, Jr. 2016. **The Moquah Barrens Research Natural Area: Loss of a Pine Barrens Ecosystem.** Gen. Tech. Rep. NRS-161. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northern Research Station. 25 p.

The Moquah Barrens Research Natural Area (RNA) was established by the Chequamegon National Forest and the Lakes States Forest Experiment Station in 1935 with a research objective well-suited to the needs of the Forest Service and the scientific understanding of ecosystem function prevalent at the time of establishment. The original research plan was never implemented, which led to a joint Forest-Station decision in 1956 to disestablish the RNA. However, that decision was never implemented. A series of management decisions made after 1956 led to the loss of the pine barrens ecosystem originally encompassed by the RNA.

This loss is not irretrievable and the work necessary to recover the original ecosystem is possible under existing RNA management guidelines. The experience of the Moquah Barrens RNA can be used by the Forest Service to improve overall management of the entire system of research natural areas. Two main areas of opportunity are identified: 1) implement an improved approach to managing official records associated with RNAs; and 2) adopt a management framework suitable for long-term ecological projects.

KEY WORDS: Wisconsin, Chequamegon-Nicolet National Forest, barrens, fire, fire-dependent ecosystem, records management, restoration, history

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