Fire Management in Yellowstone National Park

ROBERT E. SELLERS
Forestry and Fire Management Specialist

and

DON G. DESPAIN
Research Biologist
Yellowstone National Park
Yellowstone National Park, Wyoming 82190

THE NATURAL ENVIRONMENT OF YELLOWSTONE

YELLOWSTONE National Park, located in the extreme northwestern corner of the state of Wyoming, occupies an area of approximately 3,500 mi^2 (9,000 km^2) and is the central portion of a vast mountainous, upland plateau astride the Continental Divide. Elevations in the park range from 5,000 to over 11,000 feet (1,500-3,400 m). The park is characterized by several broad, forested volcanic plateaus ranging in elevation from 7,000 to 9,000 feet (2,000-2,700 m). These plateaus are bordered by mountains on the north and east sides.

The climate of Yellowstone Park is characterized by long, cold winters; short, cool summers; and a resultant short growing season. Frost occurs most nights at higher elevations; at lower elevations nights are always cool. The average temperature at Lake, near the center of the park, during the month of July is 55.2°F (12.9°C) and for January is

10.7°F (−11.8°C). Summer temperatures generally range from 40°F (4.4°C) at night into the 70's F (20's C) in the daytime. Mean annual precipitation ranges from 10 inches (254 mm) at Gardiner, Montana, to 70-80 inches (2,100-2,400 mm) along the Continental Divide in the southwest corner of the park (Dirks, 1974). Lightning occurs rather frequently during the summer. From 58 to 3 (mean=17) resultant fires have been recorded each year, from 1931 to 1974 normally during July and August.

About 80 percent of the park is forested. Lodgepole pine (*Pinus contorta* Dougl.) and spruce-fir (*Picea engelmannii* Parry-*Abies lasiocarpa* (Hook.) Nutt.) forest types predominate, followed by a smaller Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco.) zone. Nonforest vegetation is widely interspersed throughout the forest areas. Extensive grassland and sagebrush areas occur along the lower river valleys. Mesic meadows are scattered throughout the forests on moist sites, along streams and around ponds. On the upper plateau levels and mountain slopes, sub-alpine meadows are found. The limited areas above 10,000 feet (3,000 m) support an alpine tundra (Despain 1973).

MANAGEMENT CONCEPTS

Over 1,900,000 acres (770,000 ha) of Yellowstone Park are managed as wilderness. The administrative policy for the management of natural areas of the National Park system such a Yellowstone clearly stated in 1970 "The presence or absence of natural fire within a given habitat is recognized as one of the ecological factors contributing to the perpetuation of plants and animals native to that habitat. Fires in vegetation resulting from natural causes are recognized as natural phenomena and may be allowed to run their course when such burning will contribute to the accomplishment of approved vegetation and/or wildlife management objectives" (U.S.D.I. National Park Service, 1970). Such a program was initiated in Yellowstone in 1972. This paper describes the implementation and 3 years results of this concept. Research procedures implemented are also described.

BIOLOGICAL RATIONALE TO ALLOW NATURAL FIRES

Fire is a natural part of the environment that originally shaped the post Pleistocene ecosystems of Yellowstone National Park. One only has to fly over Yellowstone slowly a few times to realize what an influence fire has had in shaping this landscape. Evidence of fire is everywhere. Baker (1969) found evidence of fire beginning more than 5,000 years ago. A number of species are adapted to fire. The serotinous cones of lodgepole pines, the thick bark of Douglas-fir, and root sprouting by rabbit brush, aspen, and other species are examples. The structure and composition of some plant communities are dependent on fire, as exemplified by dense lodgepole pine and Douglas-fir stands. Fire maintains forest-grassland boundaries and maintains a natural diversity in a landscape of otherwise uniform environment. Fire creates pioneer habitat and greatly affects the rates of mineral cycling and flow.

The extent to which natural fires are controlled determinines the degree of departure from natural conditions. With suppression, changes occur in the structure and composition of many plant communities and their interaction with other segments of the biota. Forest boundaries advance, fire-susceptible species gain an unnatural prominence, and climax communities develop over unnaturally large areas. Insect and disease organisms may obtain an unbalanced advantage, creating an overabundance of litter and deadfall. This in turn changes mineral pool relationships in the undecomposed organic matter, changing soil composition. Faunal relationships may also be expected to show departures from normal, since many species of birds and mammals are adapted to plant communities that develop following fires (Despain, 1972).

Fire control action itself produces unnatural effects, including scars of fire lines, the fertilizing effect of modern retardants, and leaving unburned many acres that would otherwise have burned. Any revegetation or rehabilitation programs are also unnatural.

Two research projects have aided in understanding Yellowstone's fire ecology. Studies on succession in lodgepole pine communities carried out by Taylor (1973) begun in 1965 have indicated what can be expected in the lodgepole pine zones. He showed a 3-fold increase in species of plants, birds and small mammals in lodgepole pine stands burned 25 years earlier. Houston (1973) dated fires as early as 1525 on the northern Douglas-fir-steppe zone of the park. Historically this zone has the highest natural fire frequency in the park. Lightning fires have been suppressed in the past 80 years. This area should probably have burned over between one and four times since the establishment of the park in 1872. These two studies helped give us confidence that no permanent damage would result in allowing fires to burn, indeed fire suppression was causing departure from natural conditions.

THE NATURAL FIRE PLAN

In the spring of 1972 a new approach to fires in natural areas was instituted to allow naturally-occurring fires to run their course over some 340,000 acres (138,000 ha) of Yellowstone Park.

The area considered for allowing naturally ignited fires to run their course met the following criteria:

1. The area should be managed as wilderness.
2. Natural fires occurring in the areas must not pose an immediate threat to primary visitor-use areas such as Old Faithful.
3. Human life must not be endangered under any circumstances.
4. Lands under the management of other agencies must be protected.

The following steps were taken to fit the proposed program into the above criteria:

1. We established a characteristic behavior pattern for fires in the park from detailed records kept from 1931 to 1971. A history of project fires in the park indicated that the dominant direction of travel was to the northeast and wind was necessary for large fires to develop.
2. Areas were then selected which were east or northeast of visitor use areas. Here, under nearly all conditions, lightning-caused fires would be allowed to burn. The areas most suitable lay on the Mirror Plateau in the northeast quadrant and on the Two Ocean Plateau in the southeast quadrant. Selection of as large an area as possible was

made, using natural barriers as boundaries within these plateau areas. With the aid of maps, aerial photos, and on-the-ground surveys this was accomplished and the two areas were delineated. The northern Mirror Unit consists of approximately 191,000 acres (77,000 ha) of lodgepole pine and spruce-fir forest interspersed with open meadows and steppes lying between the Yellowstone River on the west and the Lamar River drainage on the east. The southern Two Ocean Unit includes approximately 150,000 acres (61,000 ha) of spruce-fir, lodgepole, and open meadows lying between Heart Lake on the west and the Yellowstone River on the east (Fig. 1).

3. We then analyzed the fire history of the past decade in these two areas. In 1971, four lightning fires were suppressed in this area during rather severe burning conditions. Acreage burned was negligible. By projecting these same fires through subsequently known weather conditions and burning indices, we determined that all would have probably gone out with a combined maximum acreage of about 1,000 acres (429 ha) and a minimum acreage of around 100 acres (51 ha).

One suppressed fire on the Two Ocean Unit may have consumed a maximum of 700 acres (283 ha) and a minimum of 100 acres (53 ha) had no suppression action been taken. In addition, we projected the behavior of 13 lightning fires in the Two Ocean Unit on which full suppression activity had been taken in the years 1960-69. Maximum acreage that these combined fires may have burned was estimated at about 5,000 acres (2,200 ha) and a minimum of 700 acres (283 ha) before they would have been extinguished by natural conditions.

4. The above projections, in spite of an imperfect knowledge of fire behavior, enabled us to come up with a rather subjective hypothesis that naturally-caused fires, at least in these areas of Yellowstone National Park, would have plenty of room to run their course even during periods of extreme burning conditions that exist mainly during July and August, and would extinguish themselves as naturally as they began, without endangering human life or property.

5. Much of the rest of the park was designated as conditional zones. Late in the fire season, when fall snow storms are common enough to extinguish fires before they attain large size, lightning-caused fires would be allowed to burn at the option of the superintendent and advisors.

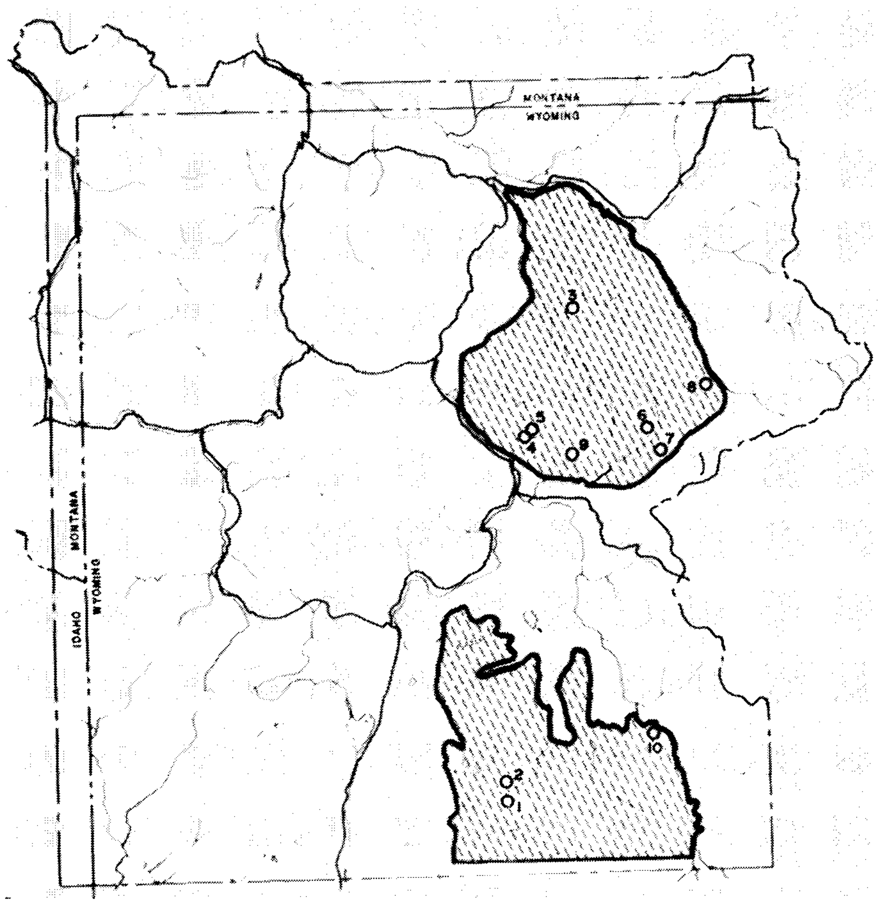

Fig. 1. Yellowstone National Park showing location of Natural Fire Zones and natural fires 1972–1974. 1=Two Ocean-1, 2=Two Ocean-2, 3=Wrong Creek, 4=Cottongrass Creek, 5=Bluff Creek, 6=Raven Creek, 7=Mist Creek, 8=Willow Creek, 9=Stonetop, 10=Trail Creek.

We then set about to test this hypothesis with our natural fire plan for these two areas. In 1972, the first year of the plan, we took suppression action on nine lightning fires in the park outside the fire management units. Two fires in the Two Ocean Unit were ignited by lightning on August 11th. Monitoring of these fires began on the day of ignition. Both went out within 2 days and burned little area. One burned a few rotten logs left from a 1931 fire and the other one burned at the base of two spruce trees (Table 1).

In 1973 we took suppression action on 23 lightning fires which included two fires of project proportions (greater than 10 acres, 4 ha) outside the units. One lightning fire occurred on the Mirror Unit. This small fire was monitored for its duration of 2 days (Table 1).

In 1974 the plan, with its accompanying hypothesis, was put to its most severe test. Precipitation in June was 34 percent of normal and by July 14th we had extreme burning conditions. July continued unusually hot and dry and 16 lightning fires outside the natural fire zones were suppressed during the month. One of these was the Fan Creek fire which consumed 470 acres (190 ha) and cost over $450,000 to suppress. On July 2nd lightning ignited a fire on the Mirror Unit. It was monitored for 2 days and was out at the end of the second day.

Toward the end of July, four lightning fires appeared on the Mirror Unit. These were all monitored. One went out at a small size but three of them — Raven Creek, Bluff Creek, and Willow Creek — became very active on July 26th when a dry cold front passed through the area. Willow Creek had not been detected until that time. These fires burned very intensely through July 28th and would have required considerable effort and expense to suppress. After the cold front had passed the Stonetop fire ignited, burned a small area and went out (Table 1).

Precipitation in August was 131 percent of normal and mean monthly temperature was 2.5°F (1.4°C) below normal at Lake. All the fires but Willow Creek went out during this period. Willow Creek smoldered in areas of deep duff accumulations and became active again in September which had only 15 percent normal precipitation.

On September 16th a lightning fire was discovered on the Two Ocean Unit in the vicinity of Trail Creek. The first day after discovery it consumed 5 acres (2 ha) of sedge meadow and secured a good enough foothold in some bordering spruce-fir to move slowly southwesterly to cover an area of about 36 acres (15 ha) by October 2nd. Winds were light from the northwest during this period. On the afternoon of October 2nd a local cold front passed through the area and carried this fire northeasterly across the Yellowstone River. Its size at 1700 on October 2nd was about 550 acres (223 ha). On Octo-

Table 1. Natural fires allowed to burn in Yellowstone National Park, 1972-1974.

Named Fire	Duration	Slope	Aspect	Elevations		Vegetation Type	Areas Burned
				Feet	Meter		
Two Ocean—1	8/11–8/13/72	—	SW	8600	2620	1931 burn in shrub stage	420 ft^2 (39 m^2)
Two Ocean—2	8/11–8/13/72	flat	NW	8400	2560	spruce-fir	110 ft^2 (10 m^2)
Wrong Creek	7/12-7/15/73	5%	NE	8400	2560	spruce-fir	222 ft^2 (21 m^2)
Cottongrass Creek	7/6–7/8/74	5-10%	SW	8600	2620	climax lodgepole	0.7 a (.28 ha)
Bluff Creek	7/23–8/14/74	30%	NE	8200	2500	lodgepole[b] and spruce-fir	50 a (20 ha)
Raven Creek	7/23–8/27/74	30%	SW	8400	2560	spruce-fir	35 a (14 ha)
Mist Creek	7/23–7/24/74	—	NW	8400	2560	spruce-fir	36 ft^2 (3-4 m^2)[a]
Willow Creek	7/23–10/10/74	50%	NE	8400	2560	spruce-fir	160 a (65 ha)
Stonetop	7/28–8/10/74	20%	E	8700	2650	whitebarked pine	0.2 a (0.1 ha)
Trail Creek	9/16–11/10/74	flat	flat	7800	2380	spruce-fir lodgepole[b] sedge meadow	580 a (235 ha)

[a] Observed from helicopter only, area is ocular estimate only.

[b] Successional lodgepole pine, about 250 years old, with spruce and fir reproduction in the understory.

ber 24th flames were still visible within the burn, but by November 10th snowfall had extinguished it (Table 1). Size increase during this period was negligible.

The summer of 1974 provided us with perhaps some of the most severe burning conditions of the past 10 years. We had ignition and hot, running fires in many of the fuel types and slope aspects typical of the park. We consider the program so far to be entirely successful. Based on past fire history and the results of this new management program we have drawn a few preliminary conclusions which we feel are valid for normal and drier than normal fire seasons such as the one just completed. Some of these preliminary conclusions are listed as follows:

1. We always have lightning occurrences and some fires result.
2. There is a very low percentage of fires ignited compared to the number of lightning strikes to the ground.
3. There is a 100 percent chance that a lightning fire will occur in either of the two management units.
4. Unique environmental conditions must occur at the time of ignition to allow the fire to continue. These conditions most often include low fuel moisture (6-10 percent), high temperatures (80°F or 27°C), low humidities (20 percent), or wind at 20 mph (32 kmph) or more.
5. Fires originating in lodgepole pine forest must reach the canopy or they remain inactive and probably go out with the next high humidity day. They run through the canopies rapidly when exposed to winds.
6. Most lightning fires originate in spruce-fir. The "sleeper" fire (one that exists for a few days before being detected) almost always can be traced to a clump of spruce-fir.
7. Fires originating in spruce-fir stands have a better chance of carrying through high humidities and calm days, even periods of rain and snow. These make dramatic runs with hot, dry winds. Winds do not have to reach the velocities that they do in lodgepole.
8. Winds occur for short periods in the afternoons and those that moved these fires were mainly caused by local cold fronts or thunderstorms. Winds of the velocity to cause fires to reach appreciable acreages occur sporadically from 8 to 10 times during the short, normal

fire season of July and August. When they do occur they are usually of short duration, lasting only a few hours.

9. Fires are most active during the hours of 1300-1700. Nights are almost always cool enough to keep fires on the ground until afternoon.

10. Fires reach their maximum acreage in spectacular fashion in a very short period of time when the wind is blowing. Between these short periods they remain on the ground and quite stationary.

11. For every day of extreme burning conditions, which include high wind, we have at least one counteracting day of wet, rainy or snowy conditions during the normal fire season at our elevations. However, extended dry periods may occur.

12. Large acreages will not burn every year. On those years when conditions are right, fires could probably be seen somewhere in the park from late spring to late fall. Both Willow Creek and Trail Creek survived some extended wet cold periods. Fires of more than 1,000 acres (400 ha) are rare and very few fires exceeded 50,000 acres (20,000 ha) in the past.

These conclusions will be further tested. The program has opened up a whole new line of thinking and opportunity for research, which hopefully will allow for future expansion of the role of natural fire in all wilderness areas of Yellowstone National Park.

RESEARCH PROCEDURES

Concurrent with the management policy of allowing naturally-caused fires to burn within defined limits a research program was implemented. The purpose of this research is to investigate the behavior of these fires and subsequent ecological changes. The data obtained will aid in understanding the role of fire in Yellowstone ecosystems and also provide better information to help predict fire behavior under given circumstances. These data will be needed to protect developments when this fire management policy is applied to other areas of the park. It will also aid in defining conditions under which fires will be allowed to burn in conditional natural fire areas.

Initial Phase Study

When a fire in one of the two natural fire management units is reported it is photographed from the air as soon as possible and video tapes made. This aerial surveillance is maintained intermittently throughout the life of the fire. Two men are dispatched by helicopter with the initial phase study kit—including a belt weather kit, a hygrothermograph, fuel stick and scales, camera and film, and other instruments as needed. Their responsibilities include recording cause, initial burning conditions, behavior of the fire, and initiating hourly weather readings.

A Fire Boss is assigned to coordinate ground action. He will supervise all personnel for safety reasons.

As soon as possible a fuel moisture stick is set up and weighed. Other fuel moisture stick stations are established if deemed necessary and feasible during the course of the fire.

During A Growing Fire

When it becomes evident that a fire is going to burn at least 40-50 acres (17-20 ha), a time lapse camera is installed to view the fire from a distance. Time interval of one minute is set. Some 15 X 25 meters permanent plots are also set out in representative communities to measure the effects of burning on the vegetation.

The corners are located and two corners diagonally across the plot are marked with steel fence posts. The plots are 15 X 25 meters with the long axis oriented parallel with the slopes, or perpendicular to the advancing front if there is little or no slope.

A priority of information to be gathered is necessary. Measurements are performed in a special sequence and as many of the measurements are taken as time allows:

1. Fuel load estimates are made. The method used is that developed by the Northern Fire Research Lab at Missoula (Brown, 1974). The lines where intercepts are tallied follow the deliniation lines of the plot. Ten lines are thus obtained each up to 10 meters in length.

2. Samples of dead fuel of the several size classes are collected in tin sample cans for moisture content determination.

3. Samples of living plant material from the needles and branches of the different tree species, leaf and twig samples from shrub, and whole plant samples from the major herb species are collected to be analyzed for both moisture content and mineral content. These are

placed in tin sample cans and weighed at a later date. Samples from each major species are taken during this step.

4. Soil samples are taken with a soil tube. Approximately 100 grams from each horizon is placed in tin sample cans.

5. Photographs are taken from each steel corner post facing toward the plot.

6. Vertical photographs are taken of each of 10 herb plots with a support (Fig. 2) that photographs a 1 meter by 1 meter area with an instamatic camera. This support is placed at 5 meter intervals along a line 5 meters from each long side of the plot. Each of these plots is marked with large nails.

7. The dbh of the trees is tallied by 5 meter wide segments according to species.

8. Shrub crown cover is determined by the line transect method along one line 5 meters from the edge. This is the same line along which the herb plots are established. That portion of the tape covered by a vertical extension of the crown to the tape is tallied to the decimeter.

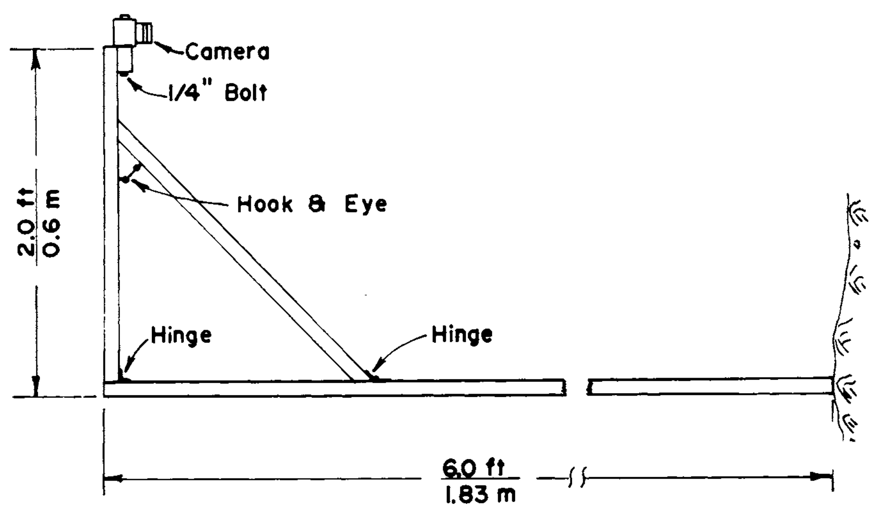

Fig. 2. Vertical platform for the photography of 1 m^2 of ground surface constructed of standard 1 X 2 inch (2 X 5 cm) pine. A Kodak instamatic camera was used, other cameras may require different vertical distances.

9. A species list and cover class estimate is compiled. The following cover class designations are used: P=1, 1=1%-5%, 2=5%-25%, 3=25%-50%, 4=50%-75%, 5=75%-95%, 6=95%-100%, (Daubenmire, 1959).

10. Water can heat integrators (Beaufait, 1966) are positioned within the plot to represent the different types of fuel accumulations. Tempilaq is used to measure duff and soil temperatures (Fenner and Bentley, 1960).

11. A survey of the plot is made for animal signs. Pellet groups, nests, burrows, cone caches, etc., are identified and located by coordinate system along sides of plot.

12. Voucher specimens of all living plant species are collected whether in flower or not. This includes mosses and lichens.

13. Surface water samples are taken from streams and lakes that are likely to be burned over. This information will provide base line data.

POSTFIRE FOLLOWUP

Followup over a several year period is essential in this project. The photopoints will be rephotographed yearly for 5 years, then on a 5-year schedule until change is slow enough to warrant a longer interval. The herb plots will be rephotographed at similar intervals.

Remeasurement of quantitative parameters on a periodic schedule will be followed to keep track of the quantitative changes in species diversity and biomass.

These methods were implemented this past fire season (1974) and found generally to be quite workable. Two men can set up a permanent plot in about 3 hours. Uncertainty as to the future activity of the fire caused problems in determining sample plot location. Five plots were set up but only one burned. There was only one period of active burning on most of the fires and during that time it is impossible to set up a plot and insure the safety of the researchers. If August had been more typical the fires probably would have burned the other plots.

Because the fire did not burn the permanent plots previously set up some permanent transects or plots will be set up in the areas that burned. These will be followed through succeeding years the same as outlined for the other plots.

The time lapse cameras were very useful. They allowed us to observe the activity of the fire in compressed time as well as see what happened when no observers were on the fire. The one minute interval with the camera shut off at night gives about 6 days on a 50-foot roll of film.

We hope that information gained this season will allow us to expand the natural fire concept to other areas within the park and thus allow more area to be managed as a more nearly natural landscape.

ACKNOWLEDGMENTS

This program would not have been instituted if it had not been for the efforts of many people. We thank Superintendant Jack Anderson who had courage enough to allow a potentially controversial approach to fire, Bill Hendrickson and others who laid much of the ground work, and Ted Bucknall who helped to formulate the present fire management plan. We also thank the numerous unnamed technicians and aids that kept and preserved records of both present and past fires.

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