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GRASS, BRUSH, TIMBER, AND FIRE IN SOUTHERN ARIZONA

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One of the first things which a forester hears when he begins to travel among the cow-camps of the southern Arizona foothills is the story of how the brush has "taken the country." At first he is inclined to classify this with the legend, prevalent among the old timers of some of the northern states, about the hard winters that occurred years ago. The belief in the encroachment of brush, however, is often remarkably circumstantial. A cow-man will tell about how in the 1880's on a certain mesa he could see his cattle several miles, whereas now on the same mesa he can not even find them in a day's hunt. The legend of brush encroachment must be taken seriously.

Along with it goes an almost universal story about the great number of cattle which the southern Arizona foothills carried in the old days. The old timers say that there is not one cow now where there used to be 10, 20, 30, and so on. This again might be dismissed but for the figures cited as to the brandings of old cattle outfits, of which the location and area of range are readily determinable. This story likewise must be taken seriously.

In some quarters the forester will find a naive belief that the two stories represent cause and effect, that by putting more cattle on the range the old days of prosperity for the range industry might somehow be restored.

The country in which the forester finds these prevalent beliefs consists of rough foothills corresponding in elevation to the woodland type. Above lie the forests of western yellow pine. Below lie the semi-desert ranges characteristic of the southern Arizona plains. The area

we are dealing with is large, comprising the greater part of the Prescott, Tonto, Coronado, and Crook National Forests as well as much range outside the Forests. The brush that has "taken the country" comprises dozens of species, in which various oaks, manzanita, mountain mahogany and ceanothus predominate. Here and there alligator junipers of very large size occur. Along the creek bottoms the brush becomes a hardwood forest.

Five facts are so conspicuous in this foothill region as to immediately arrest the attention of a forester.

(1) Widespread abnormal erosion. This is universal along watercourses with sheet erosion in certain formations, especially granite.

(2) Universal fire scars on all the junipers, oaks, or other trees old enough to bear them.

(3) Old juniper stumps, often levelled to the ground, evidently by fire.

(4) Much juniper reproduction merging to pine reproduction in the upper limits of the type.

(5) Great thrift and size in the junipers or other woodland species which have survived fire.

A closer examination reveals the following additional facts:

First, the reproduction is remarkably even aged. A few ring counts immediately establish the significant fact that none of it is over 40 years old. It is therefore contemporaneous with settlement; this region having been settled and completely stocked with cattle in the 1880's.

Second, the reproduction is encroaching on the parks. These parks, in spite of heavy grazing, still contain some grass. It would appear, therefore, that this reproduction has something to do with grass.

Third, one frequently sees manzanita, young juniper or young pines growing within a foot or two of badly fire-scarred juniper trees. These growths being very susceptible to fire damage, they could obviously not have survived the fires which produced the scars. Ring counts show that these growths are less than 40 years old. One is forced to the conclusion that there have been no widespread fires during the last 40 years.

Fourth, a close examination of the erosion indicates that it, too, dates back about 40 years and is therefore contemporaneous with settlement, removal of grass, and cessation of fires.

These observations coordinate themselves in the following theory of what has happened: Previous to the settlement of the country, fires

started by lightning and Indians kept the brush thin, kept the juniper and other woodland species decimated, and gave the grass the upper hand with respect to possession of the soil. In spite of the periodic fires, this grass prevented erosion. Then came the settlers with their great herds of livestock. These ranges had never been grazed and they grazed them to death, thus removing the grass and automatically checking the possibility of widespread fires. The removal of the grass relieved the brush species of root competition and of fire damage and thereby caused them to spread and "take the country." The removal of grass-root competition and of fire damage brought in the reproduction. In brief, the climax type is and always has been woodland. The thick grass and thin brush of pre-settlement days represented a temporary type. The substitution of grazing for fire brought on a transition of thin grass and thick brush. This transition type is now reverting to the climax type—woodland.

There may be other theories which would coordinate these observable phenomena, but if there are such theories nobody has propounded them, and I have been unable to formulate them.

One of the most interesting checks of the foregoing theory is the behavior of species like manzanita and pinon. These species are notoriously susceptible to fire damage at all ages. Take manzanita: One finds innumerable localities where manzanita thickets are being suppressed and obliterated by pine or juniper reproduction. The particular manzanita characteristic of the region (Arctostaphylos pungens) is propagated by brush fires, seedling (not coppice) reproduction taking the ground whenever a fire has killed the other brush species or reduced them to coppice. It is easy to think back to the days when these manzanita thickets, now being killed, were first established by a fire in what was then grass and brush. Cattle next removed the grass. Pine and juniper then reproduced due to the absence of grass and fire, and are now overtopping the manzanita. Take pinon: It is naturally a component of the climax woodland type but mature pinons are hardly to be found in the region; just a specimen here and there sufficient to perpetuate the species which has evidently been decimated through centuries of fires. Nevertheless today there is a large proportion of pinon in the woodland reproduction which is coming in under some of the Prescott brushfields.

Another interesting check is found in the present movement of type boundaries. Yellow pine is reproducing down hill into the woodland type. Juniper is reproducing down hill into the semi-desert type.

This down-hill movement of type lines is so conspicuous and so universal as to establish beyond a doubt that the virgin condition previous to settlement represented a temporary type due to some kind of damage, and completely refutes the possible assumption that the virgin conditions were climax and the present tendency is away from rather than toward a climax.

A third interesting check is found in the parks. In general there are two alternative hyoptheses for Southwestern parks—the one assuming chemical or physical soil conditions unfavorable to forests and the other assuming the exclusion of forests by damage. When the occasional forest tree found in any park is scrubby, it indicates in general defective soil conditions. When the occasional forest tree shows vigor and thrift, it indicates that the park was established by damage and that the soil is suitable. Nothing could be more conspicuous than the vigor and thrift of the ancient junipers scattered through the parks of the southern Arizona foothills. We may safely assume that these parks were not caused by defective soil conditions. That they were caused by grass fires is evidenced by the survival of grass species in spite of the extra heavy grazing which occurs in them and by the universal fire scars that prevail on the old junipers in them. The fact that they are now reproducing to juniper clinches the argument.

A fourth check bears on the hypothesis that the virgin grass was heavy enough to carry severe fires. The check consists in the occurrence of "islands" where topography has prevented grazing. One will find small benches high on the face of precipitous cliffs which, in spite of poor and dry soil, bear an amazing stand of grasses simply because they have never been grazed. One even finds huge blocks of stone at the base of cliffs where a little soil has gathered on the top of the block and a thrifty stand of grasses survives simply because livestock could not get at it.

The most impressive check of all is the occurrence of junipers evidently killed by a single fire from 50 years to many centuries ago, on areas where there is now neither brush nor grass and where the junipers were so scattered (as evidenced by their remains) that it is absolutely necessary to assume a connecting medium. If the connecting medium had been brush it could hardly have been totally wiped out because neither fire nor grazing exterminates a brushfield. It is necessary to assume that the connecting medium consisted of grass. It is significant that the above described phenomenon occurs mostly on

granitic formations where it is easy to think that a heavy stand of grass might have been exterminated by even moderate grazing due to the loose nature of the soil.

Assuming that all the foregoing theory is correct, let us now consider what it teaches us about erosion. Why has erosion been enormously augmented during the last 40 years? Why has not the encroachment of brush checked the erosion which was induced by the removal of the grass? Why did not the fires of pre-settlement days cause as much erosion as the grazing of post-settlement days?

It is obvious at the start that these questions can not be answered without rejecting some of our traditional theories of erosion. The substance of these traditional theories and the extent to which they must be amended before they can be applied to the Southwest, I have discussed elsewhere.[1] It will be well to repeat, however, that the acceptance of my theory as to the ecology of these brushfields carries with it the acceptance of the fact that at least in this region grass is a much more effective conserver of watersheds than foresters were at first willing to admit, and that grazing is the prime factor in destroying watershed values. In rough topography grazing always means some degree of localized overgrazing, and localized overgrazing means earth-scars. All recent experimentation indicates that earth-scars are the big causative agent of erosion. An excellent example is cited by Bates, who shows that the logging road built to denude Area B at Wagon Wheel Gap has caused more siltage than the denudation itself. Another conspicuous example is on the GOS cattle range in the Gila Forest, where earth-scars due to concentration of cattle along the water-courses have caused an entire trout stream to be buried by detritus, in spite of the fact that conservative range management has preserved the remainder of the watershed in an excellent condition.

Let us now consider the bearing of this theory on Forest administration. We have learned that during the pre-settlement period of no grazing and severe fires, erosion was not abnormally active. We have learned that during the post-settlement period of no fires and severe grazing, erosion became exceedingly active. Has our administrative policy applied these facts?

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[1] A Plea for Recognition of Artificial Works in Forest Erosion Control Policy, Journal of Forestry, March, 1921.

Pioneers and Gullies, Sunset Magazine, May, 1924.

Watershed Handbook, Southwestern District, issued December, 1923.

It has not. Until very recently we have administered the southern Arizona Forests on the assumption that while overgrazing was bad for erosion, fire was worse, and that therefore we must keep the brush hazard grazed down to the extent necessary to prevent serious fires.

In making this assumption we have accepted the traditional theory as to the place of fire and forests in erosion, and rejected the plain story written on the face of Nature. He who runs may read that it was not until fires ceased and grazing began that abnormal erosion occurred. We have likewise rejected the story written in our own fire statistics, which shows that on the Tonto Forest only about ⅓ of 1% of the hazard area burns over each year, and that it would therefore take 300 years for fire to cover the forest once. Even if the more conservative grazing policy which now prevails should largely enhance the present brush hazard by restoring a little grass, neither the potential danger of fire damage nor the potential cost of fire control could compare with the existing watershed damage. Moreover the reduction of the brush hazard by grazing is to a large degree impossible. This brush that has "taken the country" consists of many species, varying greatly in palatability. Heavy grazing of the palatable species would simply result in the unpalatable species closing in, and our hazard would still be there.

There is one point with respect to which both past policy and present policy are correct, and that is the paramount value of watersheds. The old policy simply erred in its diagnoses of how to conserve the watershed. The range industry on the Tonto Forest represents a present capital value of around three millions. Since this is about one third of the total Roosevelt Reservoir drainage we may assume roughly that the range industry affecting the Reservoir is worth nine millions. The Roosevelt Dam and the irrigation works of the Salt River Valley represent a cash expense by the Government of around twelve millions. The agricultural lands dependent upon this irrigation system are worth about fifty millions, not counting dependent industries. Grazing interests worth nine millions, therefore, must be balanced against agricultural interests worth sixty-two millions. To the extent that there is a conflict between the existence of the range industry and the permanence of reclamation, there can be no doubt that the range industry must give way.

In discussing administrative policy, I have tried to make three points clear: First, 15 years of Forest administration were based on

an incorrect interpretation of ecological facts and were, therefore, in part misdirected. Second, this error of interpretation has now been recognized and administrative policy corrected accordingly. Third, while there can be no doubt about the enormous value of European traditions to American forestry, this error illustrates that there can also be no doubt about the great danger of European traditions to Amercian forestry; this error also illustrates that there can be no doubt about the great danger of European traditions uncritically accepted and applied, especially in such complex fields as erosion.

The present situation in the southern Arizona brushfields may be summed up administratively as follows:

(1) There has been great damage to the watershed resources.
(2) There has been great benefit to the timber resources.
(3) There has been great damage to the range resources.

Whether the benefit to timber could have been obtained with lesser damage to watersheds and ranges is an academic question dealing with bygones and need not be discussed. Our present job is to conserve the benefit to timber and minimize the damage to watershed and range in so far as technical skill and good administration can do it. Wholesale exclusion of grazing is neither skill nor administration, and should be used only as a last resort. The problem which faces us constitutes a challenge to our technical competency as foresters—a challenge we have hardly as yet answered, much less actually attempted to meet. We are dealing right now with a fraction of a cycle involving centuries. We can not obstruct or reverse the cycle, but we can bend it; in what degree remains to be shown.

There are some interesting sidelights which enter into the foregoing discussions but which could not there be covered in detail. One of them is the extreme age of the junipers and juniper stumps. In one case I found a 36″ alligator juniper with over half its basal cross-section eaten out by fire. On each edge of this huge scar were four overlapping healings. The last healing on each edge of the scar counted forty rings. Within 24″ of the scar were two yellow pines of 20″ diameter just emerging from the blackjack stage. Each must have been 130 years old. Neither showed any scars, but upon chopping into the side adjacent to the juniper, each was found to contain a buried fire-scald in the fortieth ring. It was perfectly evident that these 130-year pines had grown in the interval between the fires which consumed half the basal cross-section of the juniper, and the subsequent fires which resulted in the latest series of four healings. The

fires which really ate into the juniper would most certainly have killed any pine standing only 24″ distant. The conclusion is that the juniper attained its present diameter more than 130 years ago. The size of the main scar certainly indicates a long series of repetitions of scarring, drying and burning at the base of the juniper. The time necessary to attain a 36″ diameter is in itself a matter of centuries. Consider now that other junipers killed by fire 40 years ago were found to still retain ¼″ twigs, and then try to interpret in terms of centuries the meaning of the innumerable stumps of juniper (the wood is almost immune to decay) which dot the surface of the Arizona foothills. Who can doubt that we have in these junipers a graphic record of forest history extending back behind and beyond the Christian era? Who can doubt that this article discloses merely the main broad outlines of the story?

The following instance also tells us something about the intervals at which fires occurred. I mentioned a juniper with a big scar and four successive healings of which the last counted forty rings. The last was considerably the thickest. In a general way I would say that the previous fires probably occurred at intervals of approximately a decade. Ten years is plenty of time for a lusty growth of grass to come back and accumulate the fuel for another fire. This would reconcile my general theory with the known fact that fires injure most species of grass, it being entirely thinkable for the grass to recover from any such injury during a ten-year interval.

The foregoing likewise strengthens the supposition that root competition with grass rather than fire, was the salient factor in keeping down the brush during pre-settlement days. Brush species which coppice with as much vigor as those of the Arizona brushfields could stage quite a comeback during a ten-year surcease of fire if they were not inhibited by an additional competitor like grass roots.

Whether grass competition or fire was the principle deterrent of timber reproduction is hard to answer because the two factors were always paired, never isolated. Probably either one would have inhibited extensive reproduction. In northern Arizona there are great areas where removal of grass by grazing has caused spectacular encroachment of juniper on park areas. But here again both grass competition and fire evidently cause the original park, and both were removed before reproduction came in.

It is very interesting to compare what has happened in the woodland type with what has happened in the semi-desert type immediately

below it. Here also old timers testify to a radical encroachment of brush species like mesquite and cat's-claw. They insist, however, that while this semi-desert type originally contained much grass, it never contained enough grass to carry fire. There are no signs of old fires. The encroachment of brush in this type can therefore be ascribed only to the removal of grass competition.

There are many loose masonry walls of Indian origin in the headwaters of drainages both in the woodland and semi-desert types. These have been fondly called "erosion-control works" by some enthusiastic forest officers, but it is perfectly evident that they were built as agricultural terraces, and that their function in erosion control was accidental. It is significant that any number of these terraces now contain heavy brush and even timber. Since they are prehistoric, the Indians could not have had metals, and therefore could not have easily cleared them of timber or brush. Therefore their sites must have been either barren or grassy when the Indians built them. This conforms with the belief that brush has encroached in both the woodland and semi-desert ranges.

In the brush fields of California the drift of administrative policy is toward heavy grazing as a means of reducing fire hazard. If the ecology of these California brushfields is similar to the ecology of the Arizona brushfields, it would appear obvious that either my Arizona theory or the California grazing policy is wrong. The point is that there is no similarity. The rainfall of the California brushfields is nearly twice that of the Arizona brushfields. Its seasonal distribution is different, and from what I can learn there is a great deal more duff and more herbs and other inflammable material under the California brush. It would appear, therefore, that the California tendency toward heavier grazing and the tendency in the Southwestern District toward much lighter grazing are not inconsistent because the two regions are not comparable.

The radical encroachment of brush in southern Arizona has had some interesting effects on game. There is one mountain range on the Tonto where the brush has become so thick as to almost prohibit travel, and where a thrifty stock of black bears have established themselves. The old hunters assure me that there were no black bears in these mountains when the country was first settled. It is likewise a significant fact that the wild turkey has been exterminated throughout most of the Arizona brushfields, whereas it has merely been decimated further north. It seems possible that turkeys require a certain pro-

portion of open space in order to thrive. Plenty of open spaces originally existed, but the recent encroachment of brush has abolished them, and possibly thus made the birds fall an easier prey to predatory animals.

The cumulative abnormal erosion which has occurred coincident with the encroachment of brush and the decimation of grass naturally has its worst effect in the siltage of reservoirs. The data kept by Southwestern reclamation interests on siltage of reservoirs is regrettably inadequate, but it is sufficient to indicate one salient fact, viz., that the greater part of the loosened material is at the present time in transit toward the reservoir, rather than already dumped into it. Blockading this detritus in transit is therefore just as important as desilting the storage sites. The methods of blockading it will obviously be a combination of mechanical and vegetative obstructions, and with these foresters should be particularly qualified to deal. This fact further accentuates the responsibility of the Forest Service, and indicates that the watershed work of the future belongs quite as much to the forester as to the hydrographer and engineer.