MITIGATING BUSH FIRE THROUGH THE MANAGEMENT OF FOREST PRODUCTIVITY

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Abstract
Bush fires, their causes and effects were examined. The availability of the fuel material (biomass), one of the necessary components for the initiation and sustenance of wild bushfires was studied. Investigation shows that the turnover rate is positive across the country. Over 400g in the forest zone to about 26g in the savanna zone. This means that wild bush fires can be expected in any part of the country. The dry matter and litter accumulation are also sufficient to initiate and sustain bushfires – ranging from 700g/m² to 60g/m² and 287g/m² to 116g/m², respectively, in Ekpoma. The level of dry material was expectedly higher during the dry season – particularly in December, January and February. Bush fires at this time are often very rampant, furious and dangerous, as the dry harmattan wind aids them to move at very high speed. Thus controlling the availability of the biomass can substantially help to mitigate wild bushfires initiation, severity and frequency.

Keywords: Bushfires, Biomass, Forest, Savannahs, Fuel, Frequency

Introduction
The Nigerian forests are extremely high in biomass production; however, the production varies greatly with the climate. The present situation of the forest and grassland (bush) resources in Nigeria portends great uncertainty for the future of forestry in the Country. The coniferous forest and grassland have large harvest areas with a dwindling rate of yield and production (Neenan, 1982) as the rate of lost per annum is now much greater than the rate of renewal in Nigeria and most Africa countries (Stuart, 1986).

The area occupied by tropical grassland in Nigeria is large, covering the entire Northern states. In addition, periodically inundated grasslands result from deforestation and constant annual wildfire, which is also reducing the grasslands into deserts (Momoh et al., 1996). Although some areas of the tropical grassland represent a natural climax for the prevailing climatic conditions, many tropical grasslands are anthropogenic in origin. The high yearly production coupled with the long dry season make them highly susceptible to fire. The Nigerian example has shown that protecting these areas of savannah from fire allows a rapid reversion to closed secondary forest (Odia, 2009; Hall et al., 1982; Macauley, et al., 1985; Leah et al., 1988; Agarwal, 2001). Though some fires within the tropical bushes do occur naturally, many areas do, however, have a long standing tradition of burning the vegetation to improve the grazing value of the land, to clear the land for farming and for the purpose of hunting. Fire thus plays a key role in limiting the diversity and extent of tree cover and even the grasses in the pure grassland. Fire occurrence is, therefore, very significant in the control of the quality of the forest with regard to tree density and population and any grassland, as many of the open savannas have developed under the influence of frequent burning (Laccena, 1993; Siren, 1985; Brandao , 1985). Just as fire and human activity are causing the expansion
of the grassland at the expense of forest, so also is it causing the loss of the grassland to the gain of the desert. The greenhouse effect is consequently influenced to further enhance the threat of desertification as the predictions of the major global circulation models (GCMS) suggest that there will be major climatic changes by the middle of this century (Goldammer and Crutzen, 1993; Odia, 2009). The four major natural causes of wildfire initiation are lightning, volcanic eruption, sparks from rockfalls, and spontaneous ignition (Goldammer J.G, 1994). However, many wildfires are also attributed to human sources which may be deliberate, discarded cigarettes, sparks from equipment, and power line arcs (Blair, et al, 1995). In societies practicing shifting cultivation, lands are often cleared and burnt for cultivation. The common cause of wildfires vary throughout the world. In the United States, Canada, and Northwest China, for example, lightning is the major source of ignition. In other parts of the world, human involvement is a major contributor. In Mexico, Central America, South America, Africa, Southeast Asia, Fiji, and New Zealand, wildfires can be attributed to human activities such as hunting, agriculture, and land-conversion. In Australia, the source of wildfires can be traced to both lightning strikes and human activities such as machinery sparks and cast-away cigarette butts.

Wildfires behavior and severity result from a combination of factors such as available fuels (biomass), physical setting, and weather. Wildfires prevention refers to attempts at applying methods to reducing the risk of fires as well as lessening its severity and spread. Effective prevention techniques allow supervising agencies to manage air quality, maintain ecological balances, protect resources (Krock, 2009), and to limit the effects of uncontrolled fires. In some areas, firefighting policies may permit naturally caused fires to burn to maintain their ecological role, so long as the risks of escape into high-value areas are mitigated (Scott, 2000). However, prevention policies must consider the role that humans play in wildfires, since, for example, 95% of forest fires are related to human involvement (Pyne et al., 1996). Sources of human-caused fires may include arson, accidental ignition, or the uncontrolled use of fire in land-clearing and agriculture. The ecological benefits of fire are often overridden by the economic and safety benefits of protecting structures, human life and the habitats of various plant and animal species (Wildland Fire, 2009). Wildfires suppression depends on the technologies available in the area in which the wildfire occurs. In less developed nations such as Nigeria, the techniques used can be as simple as throwing sand or beating the fire with sticks or palm fronds. In more advanced nations, the suppression methods vary due to increased technological capacity. Complete fire suppression is still the expectation of most African nations, since the majority of wildfires are often allowed to burn themselves out uncontrolled (Marlon et al., 2010; US Forest Service, 2008). While more than 99% of the several wildfires each year in Nigeria are in bushes and farms destroying crops and plantations, escaped wildfires into dwellings often cause extensive damage.

The aim of this work is to study the factors that can be controlled in areas that are prone to wild bushfires. For fire to be initiated and sustained, the trio of air, heat and fuel must be present. Fire prevention demands that one of the three should be absent where the other two are unavoidably present while fire suppression means cutting or at least limiting the supply of one of the items. In Nigeria, between the months of November and March, the weather is always hot, often in excess of 45°C, particularly in the northern part. This cannot be controlled because of the ubiquitous availability of air. The only item that can be managed is the fuel material - the biomass. This work, therefore, studied the volume and types of biomass available that may have to be controlled/managed to mitigate wild bushfires.
Materials and Methods

In executing this work, some areas in Nigeria’s rainforest, the Midwest of the south-south geopolitical zone were visited in order to determine the vegetation pattern and the quality and volume of biomass. The areas visited were: Ekpoma, Auchi, Bukuru– Jos, Lokoja, Abuja, Kafanchan, Bauchi, Gombe.

A plot of land in each of the area was demarcated into 15 units of 1m$^2$ and protected from wildfire. A unit was harvested annually, another at the end of the second year and another at the end of the third year. Net primary production ($p_n$) is the total photosynthetic gain of plant matter by vegetation occupying a unit area of ground. This must equal the change in plant mass ($\Delta W$) plus losses through death ($L$) i.e

$$p_n = \Delta W + L$$

Turnover rate: $K_r = W_y/W_{\text{max}}$

where $W_y$ = annual increment of plant material (g/m$^2$)
$W_{\text{max}}$ = maximum biomass (g/m$^2$)

$K_r$ = turnover rate (y$^{-1}$)

$K_t = 1/K_r$ = turnover time in months.

This is a common method for determining biomass yield. Annual increment of plant materials is calculated by summing all positive increment over the years. 15 pieces of 1 m$^2$ portions of lands were demarcated and cleared in January 2011 in each site. By January 2012, five of the plots were harvested by the method of stratified clipping. The yields were measured and average taken. At the end of the second year (January 2013), the process was repeated as well as at the end of the third year (January 2014). Also by personal interaction with a farmer in Ekpoma, a land that was used to farm rice and abandoned for five years was harvested in similar manner and average taken.
Results and Discussion

Above ground biomass to which this work is restricted, exhibits a seasonal, bimodal pattern, which peaks during the wet seasons. The highest values of biomass were recorded during the long rains of March to September. The results of the yield from different sites for the month of October 2011, are presented in Table 1.

Table 1: Yield for 2011 Across Selected Sites

<table>
<thead>
<tr>
<th>Study Site</th>
<th>Ekpoma</th>
<th>Auchi</th>
<th>Lokoja</th>
<th>Abuja</th>
<th>Kafanchan</th>
<th>Bukuru-Jos</th>
<th>Bauchi</th>
<th>Gombe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield (g/m²)</td>
<td>732</td>
<td>610</td>
<td>510</td>
<td>411</td>
<td>415</td>
<td>1421</td>
<td>408</td>
<td>381</td>
</tr>
</tbody>
</table>

Net Primary Productivity of the Study Sites

The net primary production of the bushes varies across the nation and the sub-region. Productivity actually varies from one site to another. Ekpoma has vegetation varying from tropical forest with production of 1292 g/m² yr, the secondary forest that is mostly around dwelling yielded, 732 g/m² yr, the area tending towards the savanna yielded 566 g/m² yr. While the areas yielding Synedrella Nodiflora, Aspilla Africana, Sida Acuta and Gomphrena Celosoidis had a production of 409 g/m² yr. Area producing Chromolaena Odorata yielded 293 g/m² yr.

Table 2 shows the annual biomass yield across the selected sites for three consecutive years. It may be noted that for a site left for three years in Ekpoma an increase in yield of 108g/m² was recorded. Auchi recorded an increased yield of 72g/m² while the forest of Jos – Bukuru yielded an increase of 804g/m² at the end of the third year. It is to be noted that the yield per year is comparatively higher the first year. For example, at the end of the first year Ekpoma yielded 732g/m² while at the end of the second year it only added 36g/m². Similarly, Auchi yielded 610g/m² after one year and 635g/m² at the end of the second years, while Bukuru yielded 1421g/m² at the end of the first year and at the end of the second year it increased to 1580g/m².

Table 2: Annual Biomass Yield (g/m²) Across Selected Sites

<table>
<thead>
<tr>
<th>Study Site</th>
<th>Ekpoma</th>
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<td>2012</td>
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<td>408</td>
<td>381</td>
</tr>
<tr>
<td>2013</td>
<td>768</td>
<td>635</td>
<td>532</td>
<td>432</td>
<td>1580</td>
<td>431</td>
<td>408</td>
</tr>
<tr>
<td>2014</td>
<td>840</td>
<td>682</td>
<td>565</td>
<td>468</td>
<td>2225</td>
<td>460</td>
<td>438</td>
</tr>
</tbody>
</table>

The quality of the biomass is, however, enhanced by age hence bushfires in these areas are often fierce and of the canopy type.

Table 1 shows that combustible materials are available across the country’s vegetation. Table 2 shows the availability or the net primary productivity of combustible materials. Using the method earlier specified, it can be seen that the turnover rate is positive across the country –over 400g in the forest zone to about 26g in the savanna zone. The dry matter and litter accumulation are also sufficient to initiate and sustain bushfire–ranging from 700g/m² to 60g/m² and 287g/m² to 116g/m², respectively. The level of dry material was expectedly higher during the dry season – particularly in December, January and February. The amount of dead vegetation steadily increased from about 66 g/m² in July 2011 to 651g/m² in December 2011 and to almost 700 g/m² in February 2012 and this is when the
bushes are burnt across Nigeria. Litter varied between 116 g/m$^2$ in July 2011 to 287 g/m$^2$ in February 2012. It can generally be seen that dry matter and litter accumulation are high in the months of January, February, and March. Bush fires at this time are often very rampant, furious and dangerous, as the dry harmattan wind aid them to move at very high speeds, destroying the flora, killing some of the fauna and chasing away the others and consequently tending to completely alter the ecosystem. The yield of dry matter and litter begin to decrease as from April due to onset of the wet season. The yield of dry matter and litter reaches its lowest level in July and August.

The comparison of the productivity at the different study sites for three years is further depicted in Figure 1.

![Fig. 1: Productivity Rate of the Study Sites](image)

From the figure, the rate of regeneration presented by annual and biannual increments, suggests that the materials have positive incremental rate and is, therefore, available continually all year round as fuel materials. The forest zone of the Benue-Plateau is again most favoured which also favours canopy fires.

The dry matter and litter accumulation in Ekpoma is described in Figure 2.
It can be seen from the figure that dry matter and litter accumulation are high in the months of January, February, and March. This period is the peak of the dry season. Also, at this period, harmattan aids the shedding of leaves and the drying up of grasses which leads to high yield of dry matter and litter. Easy ignition and sustainability of wildfires are, therefore, portended at this period.

One way to mitigate the frequency of wild bushfires is to constantly harvest the dry matter and litter. In this way, the volume of fuel available for ignition, initiation and sustenance of bushfires may be reduced to a level that is below flammability without significantly affecting the ecosystem. Furthermore, the materials mentioned above acts as fuel during the undesirable bushfires incidents. These materials could, therefore, be harvested and prepared as fuel for domestic, commercial and industrial purposes. Using these biomass materials as alternative to fuel, woodfuels, for example, will help to preserve our forests and savannas from deforestation and desertification and positively enhance the Global carbon cycles.

**Conclusion**

The work has shown that the Nigerian bushes are generally rich in biomass flora. The work depicts the availability or the net primary productivity of combustible materials. The dry matter and litter accumulation proved sufficient enough to initiate and sustain bushfires – ranging from 700g/m² to 60g/m² and 287g/m² to 116g/m², respectively. Wild bushfires occur each year in Nigeria destroying crops and plantations and changing the ecosystems while escaped wild fires into dwellings often cause extensive damage. In Nigeria damage from wildfires is in millions of dollars annually. Thus controlling the availability of the biomass can substantially help to mitigate wild bushfires initiation, severity and frequency.
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