Threat of Potential Bioinvasion in a Natural Forest in Poitan, Banaue, Ifugao, Cordillera Administrative Region

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Enumeration of a natural forest (muyong) coupled to rice terraces (payoh) in Poitan, Banaue, Ifugao resulted in the recognition of three types of vegetation after raw data from 22 plots composed of importance values of tree species were analyzed and subjected to Polar Ordination Analysis and Principal Component Analysis. The three clusters were named according to their most dominant species, namely Pinus kesiya cluster, Vaccinium whitfordii cluster and Clethra tomentella-Swietenia macrophylla cluster. Shannon-Wiener Diversity Indices (H) of 22 plots were determined and results show that Pinus plots had lower H values compared with both Vaccinium and Clethra-Swietenia H values. This is attributed to the greater shade in Pinus plots as the pine trees there are large with bigger crowns. In the two other clusters, more light reaches the forest floor allowing a diverse recruitment of light demanding tree taxa. Two of the three alien tree taxa, Large Leaf Mahogany Swietenia macrophylla and Yemane Gmelina arborea, are definitely introduced. However, the presence of a third alien tree species, Japanese Alder Alnus japonica, in the muyong is uncertain if it was also purposely introduced in the forest study area. Visually, this light-demanding wind-dispersed temperate Asian taxon is randomly numerous in open areas, thickets and secondary forests of the Cordillera highlands. The present study and survey will also be replicated in Barangays Amganad and Kinakin, Banaue, Ifugao.

Key Words: bio-invasion, importance value, muyong, payoh, Polar Ordination Analysis, Principal Component Analysis, Shannon-Wiener Diversity Index

INTRODUCTION

Any or a combination of the following enumerated factors, namely, ecological substitution (refers to man-made ecosystem taking over natural ecosystem leading to the fragmentation of natural forests), overharvesting (e.g. runaway logging and mining etc.), climate change (e.g. global warming induced by anthropogenic greenhouse gases), and bioinvasion (e.g. proliferation plus exclusive competition of exotic species versus native species) could inflict irreversible losses of biodiversity. Bioinvasion describes the proliferation and spread of alien species in a host native ecosystem. Through mutually exclusive competition, the bioinvasive species push native species to endangerment or at worse to extirpation or extinction, hence impinging possible long-term adverse impacts to the host native ecosystem. Bioinvasion is also defined as the rapid expansion of a species into regions where it had not previously existed, often as a result of human agency (Bright 1998). A country report for the Philippines on plant bioinvasion was presented by Baguinon et al. (2005) in a United Nation-Food and Agriculture Organization sponsored China conference held in Kunming, China in 2004. This paper took off from an erstwhile study being conducted in Banaue, Ifugao on forest habitats and their corresponding earthworm communities. While conducting
vegetation analysis on a natural forest coupled to rice terraces in Poitan, Banaue, Ifugao, the investigators chanced upon the presence of alien tree species, namely, Japanese Alder *Alnus japonica*, Large Leaf Mahogany *Swietenia macrophylla*, and Yemane *Gmelina arborea* all introduced by the Philippine Forestry Bureau. Temperate Asian Japanese Alder, a wind-dispersed light-demanding pioneer, was introduced postwar to cover erosion prone slopes in the Cordillera. Neotropical Mahogany introduced in 1910 and Indian Yemane in late 50’s were both introduced for commercial timber production.

In this paper, reader learns to use vegetation analysis to know if a given forest is homogenous or composed of varying habitat types. Its significance therefore, apart from imparting knowledge, lies also in providing researchers a tool they can use to study other forest ecosystems in the country. Two methods of analysis are here extended, one which can be done with calculator while the other with computer.

There are two objectives of the present paper. One objective of the paper is to communicate that it is possible to classify a given forest and stand into habitat types through vegetation analysis using Polar Ordination Analysis (Bray and Curtis 1957) and Principal Component Analysis (Pearson 1901) plus corresponding determination of their biodiversity indices, namely Shannon Wiener Diversity and Evenness Indices. The second objective is to present the discovery of alien tree species within the aforementioned natural forest stand and that there are evidences to show that one of them, the Japanese Alder *Alnusmaritima*, appears to have within the forest stand on its own.

**MATERIALS AND METHODOLOGY**

**Vegetation Sampling**

An aerial view of the muyong earmarked for study is shown in Plate 1. Twenty-two quadrats, each measured 10m x 10m, were laid-out in the selected Poitan Muyong forest. The 10m x 10m dimension is standard size for forest quadrats (Mueller-Dombois and Ellenberg 1974). Each quadrant was established by four calibrated 10 m plastic twines. The x and y twines were calibrated into 10 segments. Each segment measured one meter from the origin (0,0) to the 10th segment. The calibrated twines served also as x and y coordinates. With the unique x,y coordinates of all enumerated trees, this made possible plotting them into top-view and vertical profile maps. Trees with diameters-at-breast height (Dbh) equal or greater than 5 cm were enumerated. Their diameters were measured with diameter tape while their heights reckoned at first main branch were measured with the aid of a calibrated 20 meter pole. These two quantities served to estimate trunk volume as index of dominance, i.e. Volume = .7854 Dbh² x Height. The number of individuals per species per plot served as index to their density. The frequency of the species was reckoned based on how many times species occurred out of the four subplots per plot, for example an occurrence of 1 out of 4 scores 0.25 or 25%, 2 out of 4 scores 0.5 or 50%, 3 out of 4 scores 0.75 or 75%, and 4 out of 4 scores 1.0 or 100%.

**Computation of Importance Value of Each Tree Species**

The relative dominance of each species is provided by the formula:

\[
(\%) \text{RD}_{species} = \frac{D_{species}}{TD_{all\ species}} \times 100.
\]

The relative density of each species is computed by the formula:

\[
(\%) \text{RD}_{species} = \frac{D_{species}}{TD_{all\ species}} \times 100.
\]

The relative cover of each species is computed by the formula:

\[
(\%) \text{RF}_{species} = \frac{F_{species}}{TF_{all\ species}} \times 100.
\]

Importance Value (IV) of each species is computed by the formula:

\[
IV_{sp} = \text{RDom}_{sp} + \text{RD}_{sp} + \text{RF}_{sp} / 3.
\]

**Similarity-Dissimilarity Table and Symmetric Matrix (N x N)**

Computation of IV of all species in a plot is iterated in all 22 plots. This is compiled into a Species (M) x Plot (N) matrix with the species names on the rows while the 22 plots in columns. IV values of species per plot are entered in the cells of the M x N matrix. An example of M x N matrix is shown below. Last row contains Total IV values per plot.

<table>
<thead>
<tr>
<th>Species</th>
<th>PLOT 1</th>
<th>PLOT 2</th>
<th>PLOT 3</th>
<th>PLOT 4</th>
<th>PLOT 5</th>
<th>PLOT 6</th>
<th>PLOT 7</th>
<th>PLOT 8</th>
<th>PLOT 9</th>
<th>PLOT 10</th>
<th>PLOT 11</th>
<th>PLOT 12</th>
<th>PLOT 13</th>
<th>PLOT 14</th>
<th>PLOT 15</th>
<th>PLOT 16</th>
<th>PLOT 17</th>
<th>PLOT 18</th>
<th>PLOT 19</th>
<th>PLOT 20</th>
<th>PLOT 21</th>
<th>PLOT 22</th>
<th>TOTAL IV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pin. kesiya</td>
<td></td>
<td></td>
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<tr>
<td>Vacc. whift.</td>
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<tr>
<td>Etc.</td>
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<tr>
<td>Total IV</td>
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</tr>
</tbody>
</table>

Next, the percent similarity of any given pair of plots A and B, \( S_{AxB} \) is computed through Sorensen’s Similarity Index formula.

\[
S_{AxB} (%) = \frac{2W}{A + B} \times 100
\]

where \( w \) is the sum of the lower value IVs of species shared by compared plots A and B; the A represents the sum of IVs across species in Plot A; and the B represents the sum of IVs across species in Plot B.
Finally, the percent dissimilarity of any given pair of plots A and B, \( D_{AxB} \) is computed through the formula
\[
D_{AxB} (%) = 100 - S_{AxB} (%)
\]
Pairwise comparisons of \( N=22 \) plots take an iterated \( N \times (N - 1) \) computations, \( 22 \times 21 = 462 \). In other words, 231 are above and below the diagonal of the \( N \times N \) matrix. The diagonal of the \( N \times N \) matrix is not filled up since the diagonal elements (e.g. \( X_{1,1}, X_{2,2}, \ldots, X_{11,11}, \ldots, X_{22,22} \) in \( N \times N \) matrix example below) represent identical plots. If diagonal cells are earmarked for similarity, all will have scores of 1 reflecting self-comparison. Hence, the diagonals of either Similarity-Dissimilarity \( N \times N \) matrix or Similarity Symmetric \( N \times N \) matrix are not considered in Ordination procedures. Below is a model of a Similarity-Dissimilarity \( N \times N \) matrix with last row reserved for the total Index of Similarity (IS) values per plot.

**Plate 1.** Aerial view of the Muyong (forest) study area, Poitan, Banaue, Ifugao.

**Computation for Polar Ordination Analysis**

Ordination by Polar Ordination Analysis (POA) uses Similarity-Dissimilarity Matrix as dataset while Principal Component Analysis (PCA) uses Symmetric Similarity Matrix. Both ordination procedures end in graphing 22 plots in a two-dimensional space bounded by the X-axis and Y-axis. The Polar Ordination Analysis is simpler and can be done manually, but the Principal Component Analysis is tedious to do manually and hence it is done with the help of computer software (i.e. in Data Reduction Procedure, SPSS).

\[
x_i = \frac{L^2 + dA^2 - dB^2}{2L}
\]
where:
da is the dissimilarity of the i-th Plot with Stand Reference A
dB is the dissimilarity of the i-th Plot with Stand Reference B

The construction of the Y-axis begins with the computation of formula $e_i^2 = dA_i^2 - X_i$ which represents the misfit value of the i-th plot with the X-axis, for all plots other than the plots that have already been designated as Stand References A and B. Plot with highest $e_i^2$ value with 3 sum IS values at least 50% becomes the Stand Reference A' and its Y value is the origin, or $Y=0$. Likewise, the plot most dissimilar with Stand Reference A’ with 3 sum IS values at least 50% is designated the Stand Reference B’. The dissimilarity of Stand Reference A’ and Stand Reference B’ is the length of the Y-axis or, in other words, $L’$. To find the $Y_i$ values of the rest of the 22 plots, the formula below is used.

$$Y_i = \frac{L'^2 + dA'^2 - dB'^2}{2L'}$$

where:
da’ is the dissimilarity of the i-th Plot with Stand Reference A’
dB’ is the dissimilarity of the i-th Plot with Stand Reference B’

The position of i-th plot in the two-dimensional graph is defined by $(X_i, Y_i)$. Plotting the respective X,Y coordinates of each plot 1, 2, … i-th … 22, completes the ordination analysis. Plots with large shared species tend to be closer with one another in the graph space and together they represent a cluster or group. The results of Polar Ordination Analysis may show distinct clusters, otherwise, they overlap member plots. Sometimes some plots are not at proximate to any of the clusters and are referred to as the outliers.

**Computation for Principal Component Analysis**
The PCA uses the N x N Symmetric Similarity Matrix as dataset to input in the data manager of the SPSS Data Reduction Procedure. The 22 plots are cases, i.e. N=22. Because the Matrix is very complex, the PCA procedure makes iterated calculations and for each plot, PCA Scores are generated. The first two scores are deemed to represent the pair of independent factors that provides highest explanation to the variations among the set of 22 cases. The SPSS PCA procedure has an option to plot the respective PCA1 and PCA2 scores of each of the 22 plots. When this is done, the computer prints the graph output showing the groupings of similar plots just like in the Polar Ordination Analysis. Sometimes, the POA and PCA are comparable but sometimes there are cases when they are only partially congruent.

**Results**

**Tree Species Identification**
In the set of 22 plots, the complete set of tree species are enumerated and compiled in Table 1. Only few of the sterile plant specimens were not matched with identified voucher specimens in the Philippine National Herbarium, hence, they bear no scientific names in Table 1. For economy of space, the taxa were given species codes, for example the first column in Table 1.

A compilation of the IV of the aforementioned M species in N=22 plots is presented in Appendix Table 2. The last row is the total of IV per plot. The last column is the total of IV per species across plots wherever they are represented. The species are then sorted according to a descending order and plotted in a graph Figure 1.

From the array of species arranged according to a descending order in Figure 1, *Pinus kesiya* had the highest IV, second *Macaranga dipterocarpifolia*, third *Vaccinium whitfordii*, fourth *Clethra tomentella*, and surprisingly the exotic tree species *Swietenia macrophylla* is fifth while the open space common *Alnus japonica* is seventh.
Table 1. Tree species recorded in 22 sampling plots in Poitan, Banaue, Ifugao, arranged alphabetically.

<table>
<thead>
<tr>
<th>CODE</th>
<th>Scientific Name</th>
<th>Family Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALJAP</td>
<td><em>Alnus japonica</em></td>
<td>BETULACEAE</td>
</tr>
<tr>
<td>ASCUM</td>
<td><em>Astronia cumingiana var bicolor</em></td>
<td>MELASTOMATACEAE</td>
</tr>
<tr>
<td>BISJA</td>
<td><em>Bischofia javanica</em></td>
<td>EUPHORBIACEAE</td>
</tr>
<tr>
<td>BRECE</td>
<td><em>Breynia cernua</em></td>
<td>EUPHORBIACEAE</td>
</tr>
<tr>
<td>BRIGL</td>
<td><em>Brindelia glauca</em></td>
<td>EUPHORBIACEAE</td>
</tr>
<tr>
<td>CLTOM</td>
<td><em>Clethra tomentella</em></td>
<td>CLETHRAEACE</td>
</tr>
<tr>
<td>DEFRU</td>
<td><em>Decaspermum fruticosum</em></td>
<td>MYRTACEAE</td>
</tr>
<tr>
<td>ENGSP</td>
<td><em>Engelhardia spicata</em></td>
<td>JUGLANDACEAE</td>
</tr>
<tr>
<td>EUJAP</td>
<td><em>Eurya japonica</em></td>
<td>THEACEAE</td>
</tr>
<tr>
<td>EVOAC</td>
<td><em>Evodiaacuminata</em></td>
<td>RUTACEAE</td>
</tr>
<tr>
<td>FICME</td>
<td><em>Ficus c.f. merrillii</em></td>
<td>MORACEAE</td>
</tr>
<tr>
<td>FIPUB</td>
<td><em>Ficus c.f. pubinervis</em></td>
<td>MORACEAE</td>
</tr>
<tr>
<td>FIVAR</td>
<td><em>Ficus variegata var sycomoroides</em></td>
<td>MORACEAE</td>
</tr>
<tr>
<td>FRAGR</td>
<td><em>Fraxinus griffithii</em></td>
<td>OLEACEAE</td>
</tr>
<tr>
<td>GARLU</td>
<td><em>Garcinia luzoniensis</em></td>
<td>GUTTIFERAE</td>
</tr>
<tr>
<td>GMEAR</td>
<td><em>Gmelina arborea</em></td>
<td>VERBENACEAE</td>
</tr>
<tr>
<td>LITGL</td>
<td><em>Litsea glutinosa</em></td>
<td>LAURACEAE</td>
</tr>
<tr>
<td>LITPE</td>
<td><em>Litsea perrottetii</em></td>
<td>LAURACEAE</td>
</tr>
<tr>
<td>MACDI</td>
<td><em>Macaranga dipterocarpifolia</em></td>
<td>EUPHORBIACEAE</td>
</tr>
<tr>
<td>MACPH</td>
<td><em>Machilus philippinensis</em></td>
<td>LAURACEAE</td>
</tr>
<tr>
<td>MALRI</td>
<td><em>Mallotus ricinoides</em></td>
<td>EUPHORBIACEAE</td>
</tr>
<tr>
<td>MANGI</td>
<td><em>Mangifera indica</em></td>
<td>ANACARDIACEAE</td>
</tr>
<tr>
<td>MOOSE</td>
<td><em>Maoutia setosa</em></td>
<td>URTICACEAE</td>
</tr>
<tr>
<td>NEORE</td>
<td><em>Neonauclea reticulata</em></td>
<td>RUBIACEAE</td>
</tr>
<tr>
<td>PALFO</td>
<td><em>Palaquium foxworthyii</em></td>
<td>SAPOTACEAE</td>
</tr>
<tr>
<td>PERAM</td>
<td><em>Persea americana</em></td>
<td>LAURACEAE</td>
</tr>
<tr>
<td>PINKE</td>
<td><em>Pinus kesiya</em></td>
<td>PINACEAE</td>
</tr>
<tr>
<td>PRENA</td>
<td><em>Premna nasessosa</em></td>
<td>VERBENACEAE</td>
</tr>
<tr>
<td>PRUGR</td>
<td><em>Prunus griseus</em></td>
<td>ROSACEAE</td>
</tr>
<tr>
<td>SANKO</td>
<td><em>Sandoricum koetjape</em></td>
<td>MELIACEAE</td>
</tr>
<tr>
<td>SWIMA</td>
<td><em>Swietenia macrophylla</em></td>
<td>MELIACEAE</td>
</tr>
<tr>
<td>TOOCA</td>
<td><em>Toona calantas</em></td>
<td>MELIACEAE</td>
</tr>
<tr>
<td>TURSP</td>
<td><em>Tarpinia sphaerocarpa</em></td>
<td>STAPHYLEACEAE</td>
</tr>
<tr>
<td>VAWHI</td>
<td><em>Vaccinium whitfordii</em></td>
<td>ERICACEAE</td>
</tr>
<tr>
<td>WEILU</td>
<td><em>Weinmannia luzoniensis</em></td>
<td>CUNONIACEAE</td>
</tr>
<tr>
<td>WENLU</td>
<td><em>Wendlandia luzoniensis</em></td>
<td>RUBIACEAE</td>
</tr>
<tr>
<td>WIKOV</td>
<td><em>Wikstroemia ovata</em></td>
<td>THYMELEACEAE</td>
</tr>
<tr>
<td>DUKON</td>
<td>NOT YET IDENTIFIED</td>
<td></td>
</tr>
<tr>
<td>JAJAL</td>
<td>NOT YET IDENTIFIED</td>
<td></td>
</tr>
<tr>
<td>KUTAR</td>
<td>NOT YET IDENTIFIED</td>
<td></td>
</tr>
<tr>
<td>LABU</td>
<td>NOT YET IDENTIFIED</td>
<td></td>
</tr>
</tbody>
</table>

*alien or exotic species

Multivariate Statistical Approaches Results

Results of pairwise comparisons of 22 plots using Sorensen’s Similarity Formula and corresponding Dissimilarity are shown in Appendix Table 1. The upper half triangular matrix represents the Dissimilarity Table, while the lower half triangular matrix represents the Similarity Table, and separating the two subtables is the diagonal.

When the Similarity Table is repeated at the Upper Triangular matrix, the Table becomes a Symmetric Similarity Table. In the aforementioned Similarity-Dissimilarity Table, values at the lower triangular matrix are complementary with values at the upper triangular matrix.

Polar Ordination Analysis

The Polar Ordination Analysis (POA) result is presented in Table 2. The corresponding graph of 22 plots from their respective X, Y values is presented in Figure 2. Results show patterns of clustering for color coded plots dominated with *Pinus kesiya*, plots 1 to 9. *Pinus kesiya* plots 8 and 9 overlap with *Vaccinium whitfordii* plots 11 to 15. Plots 16 to 22 represent cases most of which are dominated by the exotic tree species *Swietenia macrophylla*. Plots 10 and 13 do not contain *Swietenia macrophylla*.

The POA has determined a pattern that involves the presence of *Swietenia macrophylla*. This is one instance that a muyong (natural forests) coupled to rice is contaminated by Large Leaf Mahogany. Long term projection of the muyongs under the presence of exotic tree species however is at present a matter of speculation. If exotic tree species advance at the expense of native species in as many localities (e.g. replicate study sites), then bioinvasion shall have been proven.

Table 2. Computed values of 22 plots in Poitan, Banaue, Ifugao along X-axis and Y-axis by Polar Ordination Analysis.

<table>
<thead>
<tr>
<th>PLOT</th>
<th>X</th>
<th>Y</th>
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<tbody>
<tr>
<td>1</td>
<td>54.36149009</td>
<td>45.58328</td>
</tr>
<tr>
<td>2</td>
<td>53.63995472</td>
<td>43.324496</td>
</tr>
<tr>
<td>3</td>
<td>51.98939-593</td>
<td>46.91869579</td>
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<td>4</td>
<td>45.26506903</td>
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<td>5</td>
<td>55.02001193</td>
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<td>7</td>
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<td>9</td>
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</tr>
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<td>22</td>
<td>12.52835389</td>
<td>20.05155</td>
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Appendix Table 1. Similarity-Dissimilarity N x N matrix of 22 plots in Poitan, Banaue, Ifugao.

![Map of 22 plots in Poitan, Banaue, Ifugao]

Appendix Table 2. Importance values of tree species in 22 plots of Poitan forest, Banaue, Ifugao.

<p>| Importance Values of tree species enumerated in <em>Pinus kesiya</em> dominated plots |
|----------------------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|</p>
<table>
<thead>
<tr>
<th>Species</th>
<th>Plot 1</th>
<th>Plot 2</th>
<th>Plot 3</th>
<th>Plot 4</th>
<th>Plot 5</th>
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### Importance Values of trees enumerated in *Vaccinium whitfordii* dominated plots

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### Clethra-Swietenia dominated plots

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Figure 1. First 20 tree species from highest to lowest importance value in Brgy Poitan, Banaue, Ifugao.

**Principal Component Analysis (PCA)**

For comparison, the PCA graph is shown below (see Figure 3). The PCA graph compared with the previous POA graph has clearer and more distinct clustering or grouping. The two graphs have more agreements than disagreement. The invasive role of the exotic tree species *Swietenia macrophylla* cannot be discounted by these two ordination analysis graphs.

**Top-view Spatial Distribution and Vertical Profile Diagram**

To dramatize further the aforementioned threat of possible bioinvasion of Ifugao muyongs, two other exotic tree species are found in the midst of native tree species. These are the Japanese Alder *Alnus japonica* and Yemane *Gmelina arborea*. Plotting the X and Y coordinates of trees give a top-view perspective of the 22 plots as shown in Figure 4. Likewise by plotting the heights and diameters of individual trees across all 22 plots yields Figure 5.
which shows the vertical profile diagram of the muyong. Both Figures show the relative positions of the three alien potentially bioinvasive species.

**Shannon-Wiener Diversity Index**

The Shannon-Wiener Diversity Index (H) value of each plot is shown in Figure 6. As expected, the Pinus kesiya plots reflect the least H values because of the relatively greater shading which limits the growth of light-demanding tree species. The *Vaccinium whitfordii* and *Swietenia macrophylla* plots have demonstrated higher H values. Trees here are of low stature and their crowns were small allowing more sunlight for the growth of light-demanding tree species like members of the Euphorbiaceae in the genera Homalanthus, Macaranga and Glochidion.

**DISCUSSION**

Although the threat of bioinvasion cannot be established with only one observation, among the three alien species found inside the Poitan forest, the Japanese Alder *Alnus japonica* could be potentially bioinvasive. The Japanese Alder is a native of temperate Asia (Orwa C. et.al., 2009) in lowland open areas. In tropical countries, the species do not tolerate warm lowlands, but thrives well above 1000 m a.s.l. where the climate is temperate. After postwar introduction of the species, it is now common in Cordillera highlands (at or above 1000 meters a.s.l.). According to the literature, the species is dispersed by wind and can be easily recruited at open and secondary growth spaces. Towards warm lowlands, the species appear to decrease until at some point they are nowhere found.

The two other species, Large Leaf Mahogany *Swietenia macrophylla* and Yemane *Gmelina arborea*, are from tropical countries (Orwa et al. 2009) and therefore are expected to respond better at warm lowlands than at cold highlands. Poitan villagers claim Large Leaf Mahogany and Yemane were intentionally planted there. Since cold climate at high elevation limits the two species, they may not become bioinvasive there. The speculation that the two species will not be bioinvasive at Poitan, Banaue, Ifugao however requires verification.

The above speculation that Yemane may not be bioinvasive at Poitan could be correct. Yemane is also not bioinvasive in lowlands because of seed dispersal problem. Yemane fruit, not eaten by birds, is heavy and cannot be blown away from mother tree. Wildlings of Yemane therefore tend to clump around Yemane mother trees. Yemane is a lowland species that is also light-demanding as well as drought resistant species native to India and Indochina (Orwa et al. 2009).

The case may be different with the shade-tolerant Large Leaf Mahogany which was introduced in the Philippines in 1914 (Ponce 1933). The winged seeds of Large Leaf Mahogany can be blown by wind away from mother tree. One capsule of Large Leaf Mahogany contains about 60 seeds (Baguinon 2011). Trees of Large Leaf Mahogany enumerated at Poitan were healthy looking. However, Large Leaf Mahogany as not bioinvasive at elevations
Figure 3. Graph of Principal Component Analysis of 22 plots (10m x 10m) randomly sampled and enumerated in Brgy Poitan, Banaue, Ifugao per plot.

Figure 4. Top-view profile diagram of the 22 plots of 22 plots (10m x 10m) randomly sampled and enumerated in Brgy Poitan, Banaue, Ifugao with tree species coded by color and shape. *Alnus japonica* had 4 individuals in Plot 4, 1 in Plot 5, 2 in Plot 15, 1 in Plot 17 and 2 in Plot 20. *Gmelina arborea* had 1 individual in Plot 18 and another in Plot 22. *Swietenia macrophylla* had 4 individuals in Plot 18, 1 in Plot 19, 5 in Plot 21 and 6 in Plot 22.
Figure 5. Vertical forest profile diagram of an Ifugao muyong (natural forest) being invaded by Japanese Alder *Alnus japonica* (ALJAP), Yemane *Gmelina arborea* (GMEAR), Large Leaf Mahogany *Swietenia macrophylla* (SWIMA). The native tree species (codes and corresponding scientific names) are listed in Table 1.

Figure 6. The Shannon-Wiener Diversity Indices of the 22 plots in Brgy Poitan, Banaue, Ifugao, brown color are *Pinus kesiya* plots, blue are *Vaccinium whitfordii* plots, and green are *Clethra tomentella-Swietenia macrophylla* plots.
pass 1000 m a.s.l. cannot be decided for lack of replicate studies in time and in space at the study area.

It was found that at the lowland northeastern slope of Mt. Makiling, Large Leaf Mahogany penetrates secondary forests at the rate of 250 meters in 70 years (Baguinon 2011) with 100 meter difference in elevation from Mahogany plantation southward to the end of the belt transect. At about 100 meters north of this Mahogany plantation, a one kilometer by 5 meters belt transect laid from due west to due east direction also showed the dominance of Large Leaf Mahogany (Baguinon 2011), although other alien tree species were also present to exact greater exclusion against native tree species. With the help of Principal Component Analysis as statistical tool (Baguinon et al. 2008), it was found out when importance value of Large Leaf Mahogany increases, forest diversity correspondingly decreases, suggesting competitive exclusion against native trees ((Baguinon et al. 2008)). Aside from the superior number of wind dispersed seeds that can be blown away from mother tree, Large Leaf Mahogany beats natives in recruitment partly because of its thick shade during wet season and also because of its leaf shedding characteristics at the start of dry season. Leaves are shed at the same time providing thick litter mat which persists until following onset of rainy season. It was found that extracts of Large Leaf Mahogany leaves dissolved in water inhibit the growth of Narra (Pterocarpus indicus) seedlings when used as watering medium (Baguinon 2011). In addition, the thick litter mat also provides a dry environment for recalcitrant seeds causing seed germination failure. While the above researches are true to lowland situation, they may or may not be true in high elevation areas.

Field data shows that Japanese Alder were represented in 5 out of 22 plots from lightly shaded to relatively open forest canopies. It is present in Pinus kesiya dominated forest type (Plots 4 and 5), in Vaccinium whitfordii dominated forest type (Plot 15) and at Clethra tomentella-Swietenia macrophylla dominated forest type (Plots 17 and 20).

In Plot 4 (H=1.47, E=.91), which had relatively shaded undergrowth due to the presence of a large pine tree, tree species including their corresponding importance values were Pinus kesiya (38%), *Alnus japonica (20%), Clethra tomentella (19%), Macaranga dipterocarpifolia (17%) and Kutario (6%). In Plot 5 (H=1.34, E=.83), which had trees little shorter but denser trees, associated tree species were Pinus kesiya (52%), Clethra tomentella (16%), *Alnus japonica (15%), Ficus cf. merrillii (9%) and Macaranga dipterocarpifolia (8%).

At Plot 15 (H=1.21, E=.87), the associated tree species were Vaccinium whitfordii (41%), *Alnus japonica (38%), Prunus grisea (11%), and Garcinia luzoniensis (10%). Trees in this plot were very low (about 10-15 meters tall) and greater light penetrated the undergrowth.

In Plot 17 (H=2.26, E=.94), associated species were numerous but trees were a little higher than 10 meters. Due to the dense trees, undergrowth is well-shaded. The importance values of tree species in Plot 17 were Toona calantas (22%), Ficus cf. merrillii (17%), Palaquium foxworthii (9%), *Mangifera indica (9%), Ficus variegata var. sycomoides (7%), Mallotus ricinoides (7%), *Swietenia macrophylla (6%), Litsea glutinosa (6%), Litsea perrottetii (6%), *Alnus japonica (6%) and Bridelia glauca (4%). Finally for Plot 20 (H=1.56, E=.97), we had *Persea gratissima (27%), Bischofia javanica (23%), Toona calantas (22%), *Alnus japonica (17%) and Garcinia luzoniensis (10%). Plot 20 is described as an open forest with greater light entering the forest floor.

**CONCLUSION**

From the above findings, the presence of *Alnus japonica* in all forest types in Poitan has been documented. More studies like this in different places in Ifugao province or even the whole Cordillera region is required to determine the extent of its bioinvasiveness. Based from present findings, this species has the potential qualities of a bioinvasive alien tree species. Indigenous highland pioneer tree species are expected to absorb keen competition against *Alnus japonica*. Contrastingly, the Yemane Gmelina arborea and Large Leaf Mahogany Swietenia macrophylla were seen in only one forest type and are spatially close to the border of the forest and trail that leads to the nearby village. After these have been planted by humans, it seems they have not gained ground to contaminate the Pinus kesiya and Vaccinium whitfordii forest types, unlike *Alnus japonica* which have trees of uneven ages inside *Pinus kesiya* and Vaccinium whitfordii. Due to the apparent random locations that *Alnus japonica* appeared at the Pinus kesiya and Vaccinium whitfordii plots in addition to their uneven ages, it is the belief of this author that *Alnus japonica* was not intentionally planted by humans at their present locations in the Poitan forest. *Alnus japonica* is growing at and around human settlements in Banaue, Ifugao and elsewhere in open areas of the Cordillera. The idea that people plant a well-represented species around human settlements in forests does not make sense, instead people would plant *Alnus japonica* where there are no trees such as in bare slopes that are prone to soil erosion.
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